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NATIONAL DAM SAFETY PROGRAM. UNION LAKE DAM (NJ-00448), ATLANTI--ETC(U)
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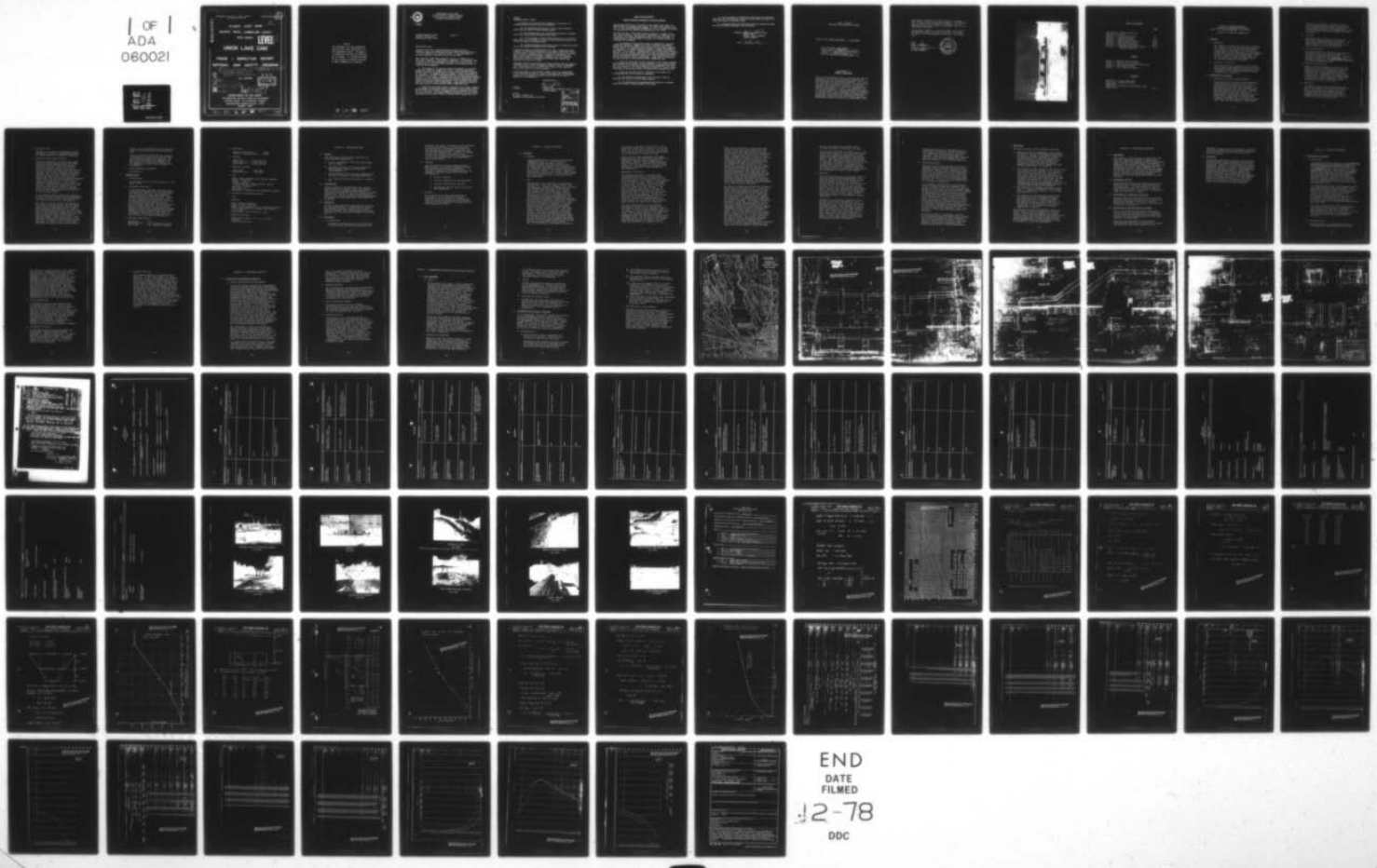

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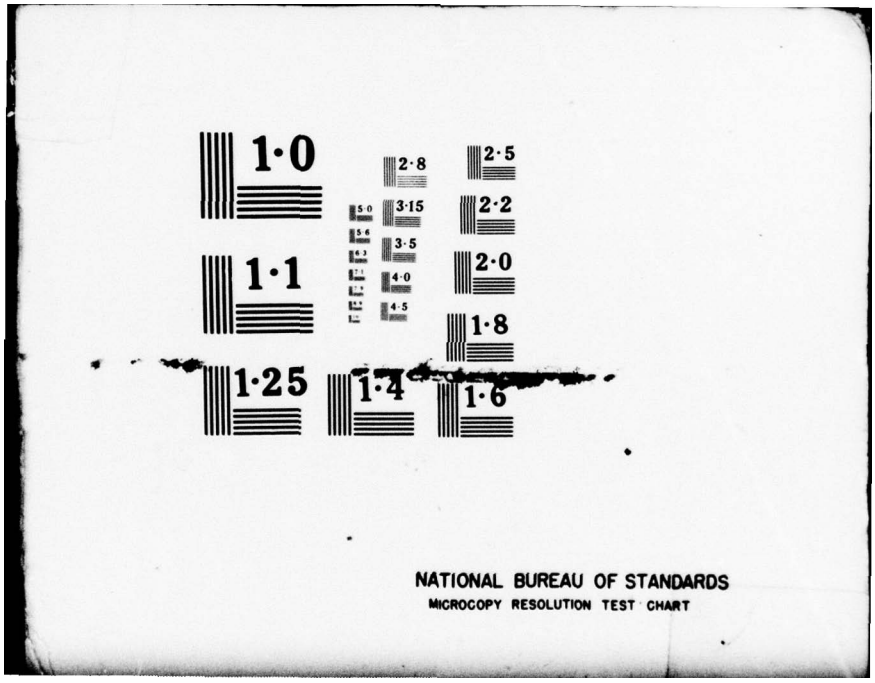
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ATLANTIC COAST BASIN

MAURICE RIVER, CUMBERLAND COUNTY

NEW JERSEY

LEVEL II

UNION LAKE DAM

PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

(6) National Dam Safety Program. Union Lake Dam (NJ-00448), Atlantic Coast Basin, Maurice River, Cumberland County, New Jersey. Phase I Inspection Report.

(15) DACW61-78-C-0124

NJ 00448

(9) Final rept.,

(10) F. Keith Jolls

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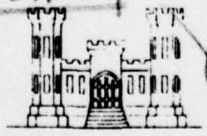

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE - 2D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

AUGUST 1978

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DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE—2 D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

IN REPLY REFER TO
NAPEN-R

Honorable Brendan T. Byrne
Governor of New Jersey
Trenton, New Jersey 08621

28 SEP 1978

Dear Governor Byrne:

Inclosed is the Phase I Inspection Report for Union Lake Dam in Cumberland County, New Jersey which has been prepared under authorization of the Dam Inspection Act, Public Law 92-367. A brief assessment of the dam's condition is given in the front of the report.

Union Lake Dam, a high hazard potential structure, is judged to be in fair overall condition. The spillway is considered to be inadequate since 61 percent of the Probable Maximum Flood (PMF) would overtop the dam. To insure adequacy of this 19th century structure, the following actions, as a minimum, are recommended:

a. The adequacy of the spillways should be determined by a qualified professional consultant, engaged by the owner, using more sophisicated methods, procedures and studies within six months from the date of approval of this report. Any remedial measures necessary to insure the adequacy of the spillway and to prevent overtopping should be initiated within calendar year 1979. In the interim, a warning system should be developed and installed whereby local Civil Defense authorities can be notified during heavy storms and the spillway gate operators provided with inflow information and incremental pool elevations from the upper gages. A gage should be installed at the Union Lake Dam to record reservoir levels during peak flows.

b. Within six months from the date of approval of this report, engineering investigations and studies should be performed to more accurately determine the extent and locations of seepage through the embankment and stability of the structure. Any remedial measures, necessary as a result of these investigations and studies, should be initiated within calendar year 1979.

c. Within one year from the date of approval of this report, the following remedial actions should be accomplished.

(1) The downstream stilling basin, below the apron, should be stabilized with riprap to prevent further scouring.

(2) The upstream slope of the dam should be protected to a greater extent with properly bedded and graded stone riprap.

(3) Clean and repair the penstock gate downstream at the burned-out power house, or, alternatively, construct a raceway around this gate to increase the capacity of powerhouse canal.

(4) Operating manuals and instructions should be prepared and posted for the left abutment sluicegates and the Fabridam.

A copy of the report is being furnished to Mr. Dirk C. Hofman, New Jersey Department of Environmental Protection, the designated State Office contact for this program. Within five days of the date of this letter, a copy will also be sent to Congressman William J. Hughes of the Second District. Under the provisions of the Freedom of Information Act, the inspection report will be subject to release by this office, upon request, five days after the date of this letter.

Additional copies of this report may be obtained from the National Technical Information Services (NTIS), Springfield, Virginia, 22161 at a reasonable cost. Please allow four to six weeks from the date of this letter for NTIS to have copies of the report available.

An important aspect of the Dam Safety Program will be the implementation of the recommendations made as a result of the inspection. We accordingly request that we be advised of proposed actions taken by the State to implement our recommendations.

Sincerely yours,

James G. Ton

JAMES G. TON
Colonel, Corps of Engineers
District Engineer

1 Incl
As stated

Cy Furn:
Mr. Dirk C. Hofman, P.E.
Department of Environmental Protection

Union Lake Dam (NJ00448)

Corps of Engineers Assessment of General Conditions

This dam was inspected on 13 June 1978 by Louis Berger & Associates, Inc. under contract to the State of New Jersey. The state, under agreement with the U. S. Army Engineer District, Philadelphia, had this inspection performed in accordance with the National Dam Inspection Act, P.L. 92-367.

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Approved: James G. Ton
JAMES G. TON
Colonel, Corps of Engineers
District Engineer

Date: 28 Sep 78

PHASE I REPORT
NATIONAL DAM INSPECTION PROGRAM

Name of Dam Union Lake Dam NJ 00448

State Located New Jersey
County Located Cumberland
Coordinates Lat.3924.1 - Long.7503.3
Stream Maurice River
Date of Inspection 13 June 1978

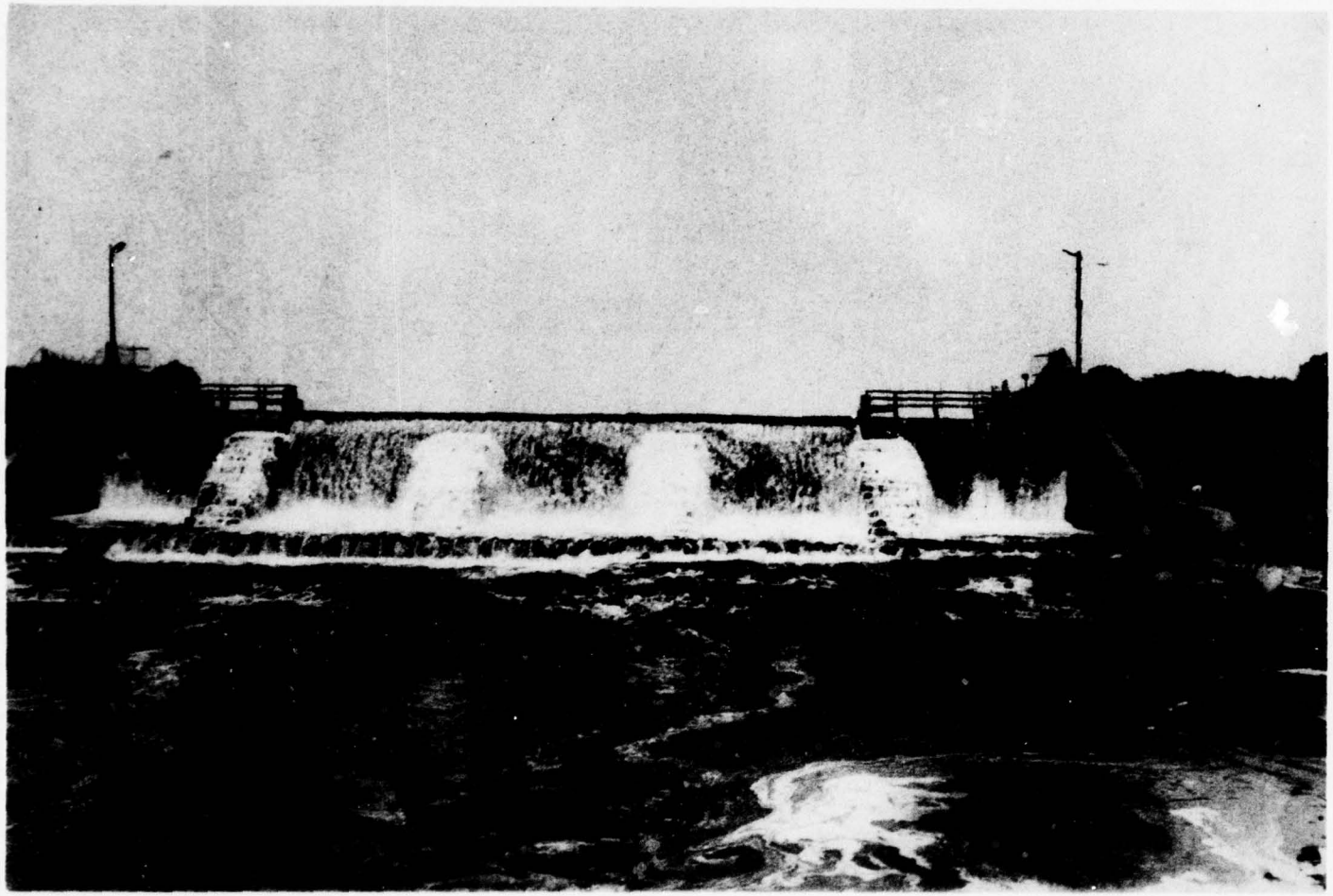
ASSESSMENT OF GENERAL CONDITIONS

Union Lake Dam appears to be in a marginally adequate structural condition but substantial seepage was observed along the downstream embankment. The dam is over 100 years old and has withstood the test of time but sufficient engineering data was not available regarding the foundations, method of construction or zoning of embankment to allow a full assessment of its term-long adequacy. Further engineering studies in the near future are recommended without reservation. A collapse could cause irreparable structural damage to the dam and significantly endanger downstream residential areas which are quite heavily populated. Recommended remedial actions to be undertaken in the

near future consist of 1) refill the stilling basin with riprap, 2) place additional riprap on the upstream face, 3) channelize and monitor the seepage at the downstream toe, and 4) repair the penstock gate at the downstream powerhouse.

The spillway capacity is 60% of the PMF design flood. The drawdown capacity is limited and can only lower the water level approximately 5 feet below the normal pool.

F. Keith Jolls P.E.
Project Manager



JUNE 1978

OVERVIEW OF UNION LAKE DAM

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PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM
NAME OF DAM UNION LAKE DAM ID# NJ 00448

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

a. Authority

This report is authorized by the Dam Inspection Act, Public Law 92-367, and has been prepared in accordance with contract FPM-36 between Louis Berger & Associates, Inc. and the State of New Jersey and its Department of Environmental Protection, Division of Water Resources. The State, in turn, is under agreement with the U.S. Army Engineer District, Philadelphia, to have this inspection performed.

b. Purpose of Inspection

The purpose of this inspection is to evaluate the structural and hydraulic condition of the Union Lake Dam and appurtenant structures, and to determine if the dam constitutes a hazard to human life or property.

1.2 DESCRIPTION OF PROJECT

a. Description of Dam and Appurtenances

Union Lake Dam is a very old earth embankment dam approximately 2000 feet long with a buttressed stone masonry spillway located about 500 feet from the right abutment. The dam impounds Union Lake, one of the largest man-made reservoirs in New Jersey. The overflow structure is 200 feet wide and is immediately upstream from a highway bridge on Sharp Avenue. The center portion of the spillway is equipped with a 118 foot long inflatable Fabridam rubber gate which controls flow. Near the left abutment, three sluice

gates are installed in a concrete housing and lead into a raceway channel which extends to the south 1000 feet into an abandoned steel penstock under a fire-gutted mill building. A canal tailrace extends from there back into the river.

b. Location

Union Lake Dam is located in the City of Millville, Cumberland County, New Jersey. The dam is built across the Maurice River approximately 13 miles from the mouth of the river at Bivalve on the Delaware Bay.

c. Size Classification

The maximum height of the dam is approximately 35 feet and the conservation storage is estimated to exceed 25,000 acre-feet. Therefore the dam is placed in the intermediate size category as defined by the Recommended Guidelines for Safety Inspection of Dams.

d. Hazard Classification

Based on Corps of Engineers criteria and the fact that in the event of failure, excessive damage could occur to downstream property together with a large potential for loss of life, the dam is unequivocally classified as a high hazard. Immediately downstream, there is a senior citizens residence, a school and trailer park as well as numerous private residences within the flood plain.

e. Ownership

The dam is owned by the Wawa Manufacturing Co., 821 Columbia Avenue, Millville, New Jersey, 08332. The Union Lake reservoir is also privately owned by this company except for a small beach area adjacent to the right abutment which has been conveyed to the City of Millville for recreational use.

f. Purpose of Dam

The dam is now used for recreation purposes although in the past, it additionally served as a power intake for industrial facilities.

g. Design and Construction History

The dam is believed to be one of the oldest earth structures constructed in New Jersey, variously reported to have been built as early as 1838 and as late as the 1870's. Historical reports indicate that it was built with horsecarts using excavated material borrowed from an area upstream of the right abutment. The original riverbed crossed the dam axis about 200 feet to the left of the present spillway but has long since been obliterated. The dam has been modified numerous times, the latest being the addition of the neoprene Fabridam in 1965. At that time, additional improvements were also made to the spillway, including the installation of steel sheeting at the spillway outflow, repairs to the upstream apron, raising of the abutments and the installation of a new cap sill on the spillway outfall.

In the original design, the top of the overflow spillway was constructed with flashboards but after a flood in 1933, these were removed and eventually replaced by the Fabridam.

The raceway canal at the east end appears to have been in existence since the late 1800's and originally terminated at a mill building (about 1000 feet downstream) where a gate and waterwheel were installed. At some later date, the waterwheel was abandoned and a 9 foot penstock was installed, leading into a building where a hydraulic turbine and generator provided electric power for mill use. After extensive damage to the raceway canal in the 1933 flood, a concrete canal intake structure was built with three 5.7 by 7.0 feet wide head gates to control flows into the raceway

canal. The canal banks were also raised and concrete walls heightened near the penstock gate.

A fire in April 1977 destroyed the generator building and the penstock control gate and the regulating controls were damaged. The gate is now inoperative and remains about half open and is plugged with debris. At the present, the entire facility appears to be abandoned.

h. Normal Operating Procedures

See Section 4

1.3 PERTINENT DATA

a. Drainage Area

The drainage area of the Union Lake Dam is 218 square miles.

b. Discharge at Dam Site

A USGS continuous recording water stage gage is installed at Norma, about 6 miles upstream from the Union Lake Dam. Its drainage area is 113 square miles and records indicate a maximum discharge of 7360 cfs (1940). There is also a tidal crest-stage partial record station downstream at Bivalve which indicated an annual maximum high tide of 6.8 feet which indicates tides would extend back to the stilling basin at the dam. The only gaging done at the dam site is for water quality. Therefore, recent flow records are unavailable. However, earlier records and Dam Applications indicated a design flood of about 6200 cfs was adopted. The total spillway capacity is 19,000 cfs with the present configuration.

c. Elevation (Above M.S.L.)

Top of dam	-	35.0	
Recreation pool	-	27.0	(Fabridam inflated)
Normal pool	-	24.6	(Fabridam deflated)

d. Reservoir

Length of maximum pool - 18,500
Length of recreation pool - 14,500

e. Storage

Normal pool - 11,600 acre-ft.
Recreation pool - 13,500 acre-ft.
Top of dam - 25,800 acre-ft.

f. Reservoir Surface

Top of dam - 1,815 acres
Recreation pool - 850 acres

g. Dam

Type - Earth embankment with masonry spillway
Length - 2,000 feet
Height - 35 feet
Freeboard between normal reservoir and the top of the dam - 8 feet
Top width - 20 feet
Side slopes 2:1
Embankment - composition and compactness unknown

h. Diversion and Regulating Tunnel

None

i. Spillway

Type - buttressed masonry
Length of weir - 200 feet
Center crest elevation - 27.0 (Fabridam inflated)
Spillway equipped with Fabridam (118' long x 2.5' high)
Side spillway crest elevation - 26.0±

j. Regulating Outlets

Three sluice gates (5.7' x 7.0') at left abutment.
Invert Elevation 20±.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

The information available for review for the Union Lake dam consisted of:

1) U.S.G.S. Quadrangle - Millville, New Jersey scale 1:24000.

2) Dam Application No. 578, State Division of Water Policy & Supply, 1965 (various correspondence).

3) Three drawings of 1965 spillway modifications by Justin & Courtney, Consulting Engineers.

4) 1973 inspection report by Neville C. Courtney, P.E.

2.2 CONSTRUCTION

Little information was obtained on the actual construction as no as-built plans were available. There have been no apparent major structural modifications except the concrete headgate structure installed in 1933 and the spillway modification work in 1965. However, numerous other modifications and repairs have been made over the extended life of the dam.

2.3 OPERATION

The dam is operated as a simple overflow facility by Wawa Manufacturing Co. personnel who regulate the Fabridam inflation. Because the penstock gates are blocked, the bulkhead gates at the left abutment are not being used at present (see Section 4).

2.4 EVALUATION

a. Availability

Sufficient engineering data is not available to fully assess the design of the dam or to

determine its safety. Nothing is known regarding the geotechnical make-up, including zoning, relative density and permeability except that the embankment has withstood a hydraulic head for over one hundred years. However, no records or data were available regarding earlier failures and reconstruction or more importantly, if the crest elevation was ever raised above the earliest height.

b. Adequacy

The data relating to the spillway structure modifications is considered inadequate to base any assessment upon design procedures or stability. Additional information required for complete evaluation should include but not be limited to:

1) As-built drawings

2) Material properties of the embankment

3) Records of piezometric readings

4) Borings and test pit data on the spillway foundations.

c. Validity

The validity of the 1965 engineering data available is not challenged but further investigations are required to ascertain the physical conditions and assess the structural stability of the remainder of the dam below the 1965 rehabilitation work.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General

Visual inspections of the Union Lake Dam were conducted on June 14, 21 and 28 with a subsequent inspection made on July 19 to ascertain seepage conditions during periods of lower flow. The seepage rates observed along the downstream embankment at earlier inspections were of major concern. The overall inspection revealed the facility to be in fair condition and satisfactorily maintained in working order except the blocked penstock gate at the lower end of the power canal.

b. Dam

The dam crest is at elevation 35, providing a freeboard of 8 feet over normal storage level elevation 27. Although no drawings are available, the embankment on each side of the spillway has a crest width of between 15 to 20 feet, and upstream and downstream slopes varying from 1.5 to 1 to 2 to 1. The dam is heavily overgrown with scrub oak and underbrush, but such growths are normally removed every two to three years according to operating personnel. Some growth is permitted to remain as a deterrent to slope damage resulting from erosion, motor-bike trail rutting and vandalism. A band of riprap about 5 feet in vertical measurement has been randomly placed along the upstream slope of the dam, extending from 2 feet below normal reservoir level to about 3 feet above normal. The riprap is apparently not bedded on gravel and would undoubtedly be displaced during high wave action. As previously stated, the location of the spillway (which now lines up with the present river alinement downstream) was not in the original riverbed which crossed the dam axis about 200 feet to the east. Thus, the maximum section height of the dam is

at a point to the left of the spillway, being constructed from roughly elevation -5 below sea level to the top crest elevation. The original river area below the dam has since been filled in and the channel is completely gone.

Because of the heavy undergrowth and swampy areas below the dam, meaningful examination for seepage through or below the dam was very difficult. However, small streams just below the dam were issuing into the river from both sides, and it is suspected that these streams originate as springs or seeps through the dam foundation.

c. Appurtenant Structures

The spillway consists of a 35 foot high buttressed masonry wall overflow structure located so as to discharge directly into the river downstream. It is about 200 feet long and is constructed of stone masonry. The exposed height is about 22 feet. The footing depth is unknown but is believed that it rests in part on a timber and rock crib base. The crest is about 5 feet wide at the top, and the exposed downstream face is on about a steep 2:12 batter. The slope of the upstream side of the wall is unknown. The wall is braced on its downstream face by four 10 foot wide masonry buttresses spaced at 42'-6" centers. Backfill is placed upstream and level with the top of the wall and a concrete apron extends out about 30 ft. upstream.

The 1965 rehabilitation of the spillway consisted of repairs to the upstream apron, the addition of the rubber "Fabridam" gate at the crest, a raising of the abutment walls, and a resurfacing and extension of the downstream apron. The Fabridam replaced an ancient flashboard system and provided an unobstructed, adjustable weir. The top masonry course under the Fabridam area of the spillway was removed and reset and coated with epoxy. The crest under the Fabridam is at elevation 24.6±.

Steel sheet piling (ZP27) cutoff walls were driven at the upstream and downstream ends of both aprons and a dentated end sill was constructed at the lower end of the downstream apron. The sheeting at this end is 22 feet long according to records. A six foot concrete fillet was added at the intersection of the overflow wall and the apron to deflect the overflowing nape onto the apron(and possibly to increase the stability of the wall). The addition of steel sheeting at the north end of the upstream apron was for the purpose of preventing erosion and an undermining action which had scoured a deep hole in the upstream embankment. The downstream apron resurfacing and extension presumably was made to afford more protection against impact and sweepout forces and the dentated sill was provided to deflect high velocity flows away from the downstream riverbed. The downstream steel sheet piling affords additional protection of the apron against undermining.

The top of the overflow spillway was originally constructed to elevation +26.0. In order to obtain additional reservoir storage, a flash-board structure walkway was placed atop the wall so that flashboards (up to 2 feet high) could be installed. During the 1933 flood, great difficulty was experienced in removing the flashboards, and floating debris hung up and clogged the support structure, threatening the safety of the dam. As a result, it was decided to replace approximately 118 feet of the center portion of the overflow with the inflatable rubber gate, which could be lowered completely and thus provide an unobstructed floodway for passing debris during heavy flows. The 1.5 foot capstone of the overflow wall was removed and the 2.5 foot high rubber dam was installed, with its top at elevation 27.0 when inflated. Two 42 foot long end sections of the wall remained at elevation 26.0 and 12 inch wide flashboards were provided to control the reservoir up to elevation 27.0. For present reservoir operation, the rubber gate is only partly inflated and some

flow is maintained over the gate, mainly in order to prevent vandalism to the gate.

As previously mentioned in Section 1.2.g., the canal intake structure (3-5.7'x7.0' head gates) at the east abutment is operational but the channel is blocked downstream at the penstock (which is open about half way but clogged with debris). The capacity of these outlet sluices is limited as the penstock control gate capacity, if repaired, is limited by the power plant turbine (about 300 cfs). Representatives of the owners informed the inspection team that the penstock gate and electrical lifting devices were scheduled for repair in late summer.

d. Reservoir

The Union Lake Reservoir is privately owned by the Wawa Manufacturing Company except for a small beach area on the right abutment which has been deeded to the City of Millville. Several private residences are also situated on the left bank of the reservoir at or below elevation +35.0 and a rise in the reservoir above elevation 30± could possibly flood these homes. However, the reservoir is maintained at nearly a constant level, since withdrawals from storage below spillway level is now impossible because of the breakdown of bypass facilities.

Upstream from Union Lake, there are a series of smaller reservoirs constructed on the Maurice River and its tributaries which could conceivably cause a chain reaction if any of the dams impounding these storages collapsed. These reservoirs are Rainbow Lake, Willow Grove Lake, Malaga Lake, Iona Lake, Franklinville Lake, Silver Lake and Wilson Lake. Their condition and storage volumes are not known, but they could exert a considerable affect on Union Lake surcharge storage even discounting an unusual flood event.

Recreational activity at the reservoir is confined to sailboating, bathing and fishing, with speedboats and water skiing prohibited (to reduce wave action) along the dam and shoreline. The reservoir banks slope gradually from the shoreline and landslides into the reservoir would be a very remote possibility.

e. Downstream Channel

The Maurice River below the dam is subject to tidewater from the Delaware Bay with a daily variation of about 4.5 feet. Immediately downstream below the dam there is the Sharp Street bridge and a concentration of mill buildings within the flood plain, a senior citizen high rise residence and a school (situated at about elevation 10) about 0.7 of a mile downstream from the dam. A trailer park is located about 0.5 mile further downstream.

In its present configuration, the downstream apron is elevated above the riverbed as well as the tailwater of both low and high tides and sweepout of the apron area occurs whenever flows greater than about 600 cfs pass over the spillway. No computations for stage-discharge tailwater relations have been made for the downstream river channel, and it is not known if a tailwater could build up sufficiently from higher flows to produce a hydraulic jump on the apron and thereby dissipate the higher energy flows to the extent that scour below the apron can be prevented. Attempts are now made periodically to replace scoured riprap below the apron, but at the time of the inspection, scour areas as much as 8 feet below the apron level were observed.

For better hydraulic performance, the downstream apron should be depressed below tailwater for a sufficient length to form a hydraulic jump for near maximum discharges. This would require an apron some 15 feet lower than its present level and would represent a major reconstruction project of questionable value.

3.2 EVALUATION

The major concerns of the inspection team were:

1) Seepage through the embankment; its location and amount. Further field observations should be made to ascertain the phreatic surface and to establish channel locations to prevent further erosion. As might be expected with such an old embankment, the seepage water observed was clear and does not exhibit excessive velocities but the amount indicates further investigation is warranted;

2) The stability of the embankment and spillway with the higher reservoir surface. It is fairly certain that no analyses were ever made of the dam. After further stability analyses are completed, additional upstream protection may be required and the downstream slopes may need regrading and compaction. Additional free-draining material may be required to keep the phreatic line within the embankment section or toe of embankment trenching and backfilling with granular material may prove necessary;

3) The inadequacy of drawdown facilities in the event of a developing weakness in the embankment or collapse of a section of the spillway structure (see 5.1.e).

4) The condition of the spillway stilling basin and downstream apron (although the repair work undertaken in 1965 appears to operate satisfactorily and is in good condition). The masonry buttresses and main wall are very old and due to the overflow at the time of inspections, it was difficult to closely examine their condition.

The seepage and spillway foundations remain the items of major concern recommended for further study. From the age and history, the present reservoir pool elevation appears to be satisfactory as the phreatic line does not obtrude from the downstream embankment. Further analysis would qualify whether the remedial measures set forth in paragraph (2) above are applicable.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

The reservoir is operated by the owners with two part-time employees available to operate the gates, to patrol the reservoir, and to periodically examine the dam and appurtenances for damage or vandalism. No manuals or instructions for operation and maintenance of the dam or appurtenances are documented or posted. Such procedures are either carried out on oral direction or at the discretion of the operators. In the event of unusual flood events, the Millville Police Department is alerted or on call as needed for warning or other services.

4.2 MAINTENANCE OF DAM

Maintenance and repair of the dam are carried out whenever funds are available, principally on an as-needed basis. The heavy growth of scrub oak and underbrush which cover the dam are removed about every two years. Some growth is permitted to remain to stabilize the slopes.

4.3 MAINTENANCE OF OPERATING FACILITIES

The only operating facilities in use are the air compressor and water pump required to inflate and deflate the Fabridam. There is no regular maintenance schedule in operation, and repairs are carried out as necessary.

4.4 DESCRIPTION OF WARNING SYSTEM IN EFFECT

There is no formal warning system in operation nor are there any instructions on the operation of the Fabridam should the water level need to be lowered. The safe operation during a high water situation is questionable.

The New Jersey Department of Environmental Protection records indicate that in 1970, a micro-wave detection system was installed on the

Fabridam to assist in protecting against vandalism. This was not observed during the field inspection and therefore the status or condition of the device is unknown.

4.5 EVALUATION

The present operational procedures and safeguards during periods of heavy flows are virtually non-existent and therefore are believed to be totally inadequate. There is no formal system of warning downstream residents in case of dam misoperation, failure or high water emergency. Maintenance and operational procedures should be improved and annual inspections with written reports, and responsive record keeping should be provided for review, especially in view of additional community growth in the downstream areas. A staff gage should be installed at the spillway, correlated to the crest elevation and read during site inspections and periods of heavy rainfalls.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. Design Data

In accordance with the criteria in the Recommended Guidelines for Safety Inspection of Dams, it has been determined that the dam at Union Lake is intermediate in size and is placed in the high hazard category. Accordingly, the spillway design flood was determined to be the probable maximum flood (PMF) and the inflow hydrograph was calculated from the probable maximum precipitation (PMP) which was obtained from Hydrometeorlogical Report No. 33. Union Lake Dam has a maximum spillway discharge capacity with the Fabridam deflated of 19,000 cfs without overtopping the dam.

In accordance with Corps of Engineers directives, the inflow hydrograph and flood routing were performed utilizing the HEC-1 computer program. Peak inflow to the reservoir for the PMF was 31,490 cfs indicating that the discharge capacity of the dam is inadequate. The PMF was routed through the reservoir and the discharge decreased from 31,490 cfs to 31,440 cfs. On this basis the spillway discharge capacity will accommodate approximately 60% of the SDF.

The results obtained from the flood routing indicate the water level in the reservoir will reach elevation 35 (the top of the dam) approximately sixty six hours after the start of the precipitation event. The discharge at that point in time would be approximately 19,000 cfs.

b. Experience Data

Although there is no recorded stream flow data immediately downstream from Union Lake

Dam, there is a gaging station 6 miles upstream at Norma which encompasses 59% of the total drainage area. The maximum discharge at this station was 7360 cfs, which occurred on September 2, 1940. Log Pearson type III flood frequency analyses were performed by the U.S. Geological Survey utilizing station skews on the historical data available from the station. The 100-year and 500-year floods are 4,820 cfs and 11,300 cfs respectively. Adjusting these values on the basis of the ratio of the respective drainage areas for Norma and Union Lake Dam results in 100-year and 500-year flood discharges of 9,300 cfs and 21,800 cfs respectively at Union Lake. Thus, it is estimated that the spillway can accommodate approximately 87% of the 500-year flood event.

c. Visual Observations

On inspection, the spillway appeared to be in adequate condition, with the inflatable Fabridam functioning well. However, there are several deficiencies, the more noticeable being the inadequacy of the sluice gates to draw-down the reservoir in the event of a weakness developing in the embankment, and the perched downstream spillway apron which would subject the channel to sweepout for releases in access of about 600 cfs. Further, the capacity of the spillway, as presently constructed is deficient for handling floods of more than those of moderate frequency.

d. Overtopping Potential

The spillway would probably accommodate any flood below a 500-year frequency event overtopping. However for any flood of greater magnitude, overtopping would occur. In the case of the design flood (PMF), overtopping would occur in about 66 hours. Therefore, based on the criteria used, there is great potential for overtopping.

e. Drawdown Potential

The drawdown capacity is practically non-existent. As previously stated, the three head gates at the left abutment are operative and have a capacity of roughly 950 cfs but their outlet channel is blocked downstream at the powerhouse penstock gate. However, even if the canal is rerouted (bypassing the penstock) the three head gates (whose invert is approximately elevation 20) could only reduce the reservoir level to about elevation 21 or 22 which is only a few feet below the main spillway crest. Hence, a hydraulic head of about 20 feet would remain on the dam upstream face. Drawdown calculations indicate that about nine days will be required to lower the reservoir level from elevation 25 to elevation 21. These calculations assume no inflow to the reservoir and emphasize the gross inadequacy of the drawdown capacity of the sluices.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations and Data Review

Union Lake dam was designed and constructed at a time when design concepts were considerably different from modern day methods and standards, and it would be expected that such considerations as design flood quantities, stability evaluations, etc. would vary considerably from presently accepted criteria. In 1965, certain engineered modifications were made to the spillway and the canal headworks were added to enhance the operation of the structure. It is not known if any earlier modifications were made on the dam since it was originally constructed. However, it is a certainty that no stability analysis of the original dam was made at the time of construction, and no evidence is available to conclude that a stability check was made in recent years. The best evidence available that the dam is stable is the fact that it has remained intact for the last 100 years under the normal reservoir loadings imposed, without serious incident. It is not known if stability could be maintained under greater loads which would be imposed by a much higher reservoir surcharge.

The earth dam is a very old installation, and its structural stability at the time of construction was undoubtedly determined by empirical concepts rather than by any type of analysis. The strength and permeability characteristics of the embankment material and the zoning of such material (if any) is not known, so a meaningful analysis is impossible.

The composition and condition of the spillway, foundation and footings are unknown, except that the footings are conjectured to be a rock-filled timber crib. However, for normal loads imposed on the structure since it was

built, no unusual incidents have been documented to indicate instability or failure. The stability of the spillway overflow wall, in the event of a flood event when surcharge head nears the top of the dam, could not be computed unless information on footing dimensions were available.

b. Operating Records

The dam appears to have performed satisfactorily under all flooding conditions although it is completely unknown what failures or repairs have occurred in past history (such as in 1933, when it proved difficult to remove the flashboards on the spillway which eventually led to the installation of the Fabridam).

c. Post Construction Changes

It appears there have been no further modifications since the 1965 installation of the Fabridam and related spillway modifications. The original Fabridam was destroyed by vandals in 1971 and replaced with a new one.

e. Seismic Stability

Although the dam is in earthquake Zone 1 and thought to have negligible suspectibility to seismic forces, they should be included in further stability studies as a matter of record. The foundation conditions for the dam consist mainly of intermixed silt, sand, clayey silt and clayey sand with some gravel. Increasing percentages of coarse sand and gravel are present with depth. Internal drainage is somewhat impeded by the silty-textured, lower soil layers. However, it is believed that liquefaction of the embankment would not be a consideration. The depth to bedrock is estimated at greater than 100 feet throughout Cumberland County.

SECTION 7 - ASSESSMENTS/RECOMMENDATIONS/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety

On the basis of the Phase I visual examination, the Union Lake dam appears to be marginally adequate for normally expected flood conditions although the spillway is incapable of passing the design flood. The dam is built of stable but unknown construction material. The hydraulic review indicates that the spillway capacity should be increased to preclude an uncontrolled overtopping of the embankment portions of the dam and to safeguard against an abnormal rise in reservoir level which could endanger the spillway structure. A collapse of the spillway could cause irreparable structural damage to the dam, the downstream bridge and residential areas and be a significantly serious danger to human life. Overtopping of the embankment could heavily damage the downstream slopes which are unprotected and unevenly graded.

Except for the inadequate spillway capacity, the seepage observed and the lack of drawdown facilities, no inherently detrimental conditions were observed to render an inadequate assessment. However the long-term stability remains extremely doubtful until further studies are completed. This assessment is subject to the limitations inherent in the visual inspection procedures stipulated by the Corps of Engineers.

b. Adequacy of Information

Except for what was visually observed, little information was otherwise available as no design data, design drawings or studies were located except for the 1965 rehabilitation plans which delineate only the repair work undertaken at that time. The hydraulic data presented in the 1965 Dam Application is

is inadequate except for the spillway capacity rating. No recent surveys have been made and performance information is believed to be non-existent. The availability of data is therefore deemed to be inadequate.

c. Urgency

Further investigations should be undertaken in the near future as a collapse of this dam could conceivably wash out the hydraulically substandard (in relation to the SDF) Sharp Street bridge immediately downstream and would significantly increase the hazard to loss of life and damage to property.

d. Necessity for Further Study

Because the structural stability cannot be established with reasonable reliance, due to the lack of pertinent data, the obtaining of additional information and the undertaking of further studies is recommended without reservation.

7.2 RECOMMENDATIONS/REMEDIAL MEASURES

It is recommended that further studies be initiated in the near future regarding foundation and structural conditions as the dam is classified in the high hazard category and its spillway is able to pass only 60% of the PMF design flood. Further studies are considered essential to completely assess the stability and to determine if the dam constitutes a hazard to human life and property in view of its uncertain structural condition.

a. Recommendations

- On the basis of visual examination and hydraulic calculations, improvements to the spillway capacity are warranted.

  Alternatives that might be considered include the construction of auxiliary crest spillway or the lowering of the overflow sill and providing a higher gate opening.

- The downstream stilling basin below the apron should be stabilized with riprap to prevent further scouring.

- The upstream slope of the dam should be protected to a greater extent with properly bedded riprap.

- Channelize the seepage flows at the downstream toe and regrade or flatten the embankment slopes if it is found the phreatic line obtrudes from the surface. Seepage analyses would require a full range of soils investigations before exact corrective measures could be analyzed, recommended and undertaken.

- Clean and repair the penstock gate downstream at the burned-out power house, or, alternatively, construct a raceway around this gate to increase the capacity of powerhouse canal.

b. O&M Maintenance and Procedures

Operating manuals and instructions should be prepared and posted for the left abutment sluicegates and the Fabridam. A warning system should be developed and installed whereby local Civil Defense authorities can be notified during heavy storms and the spillway gate operators provided with inflow information and incremental pool elevations from the upper gages. A gage should be installed at the Union Lake Dam to record reservoir levels during peak floods and to assist in monitoring flows during storms.

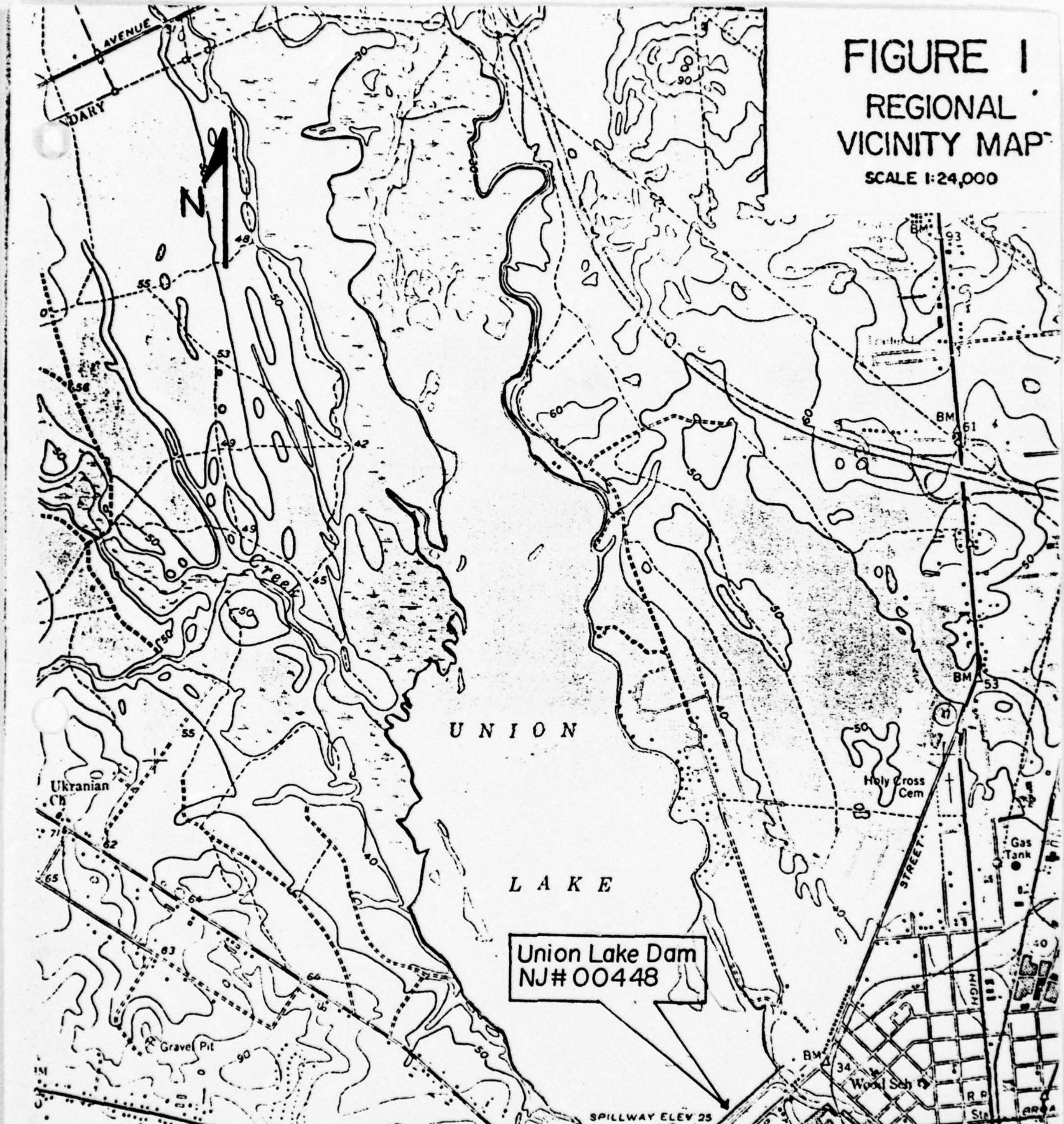
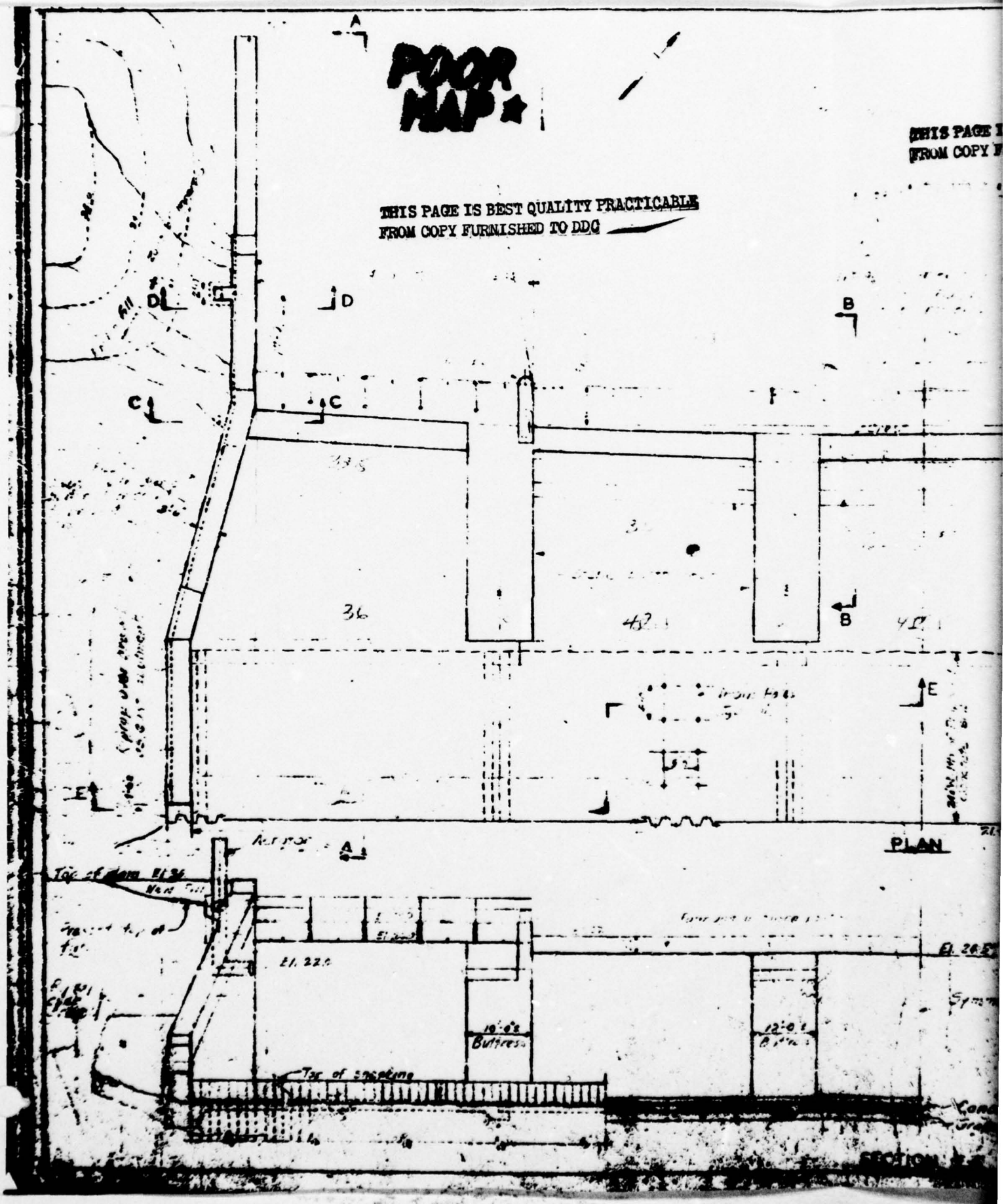
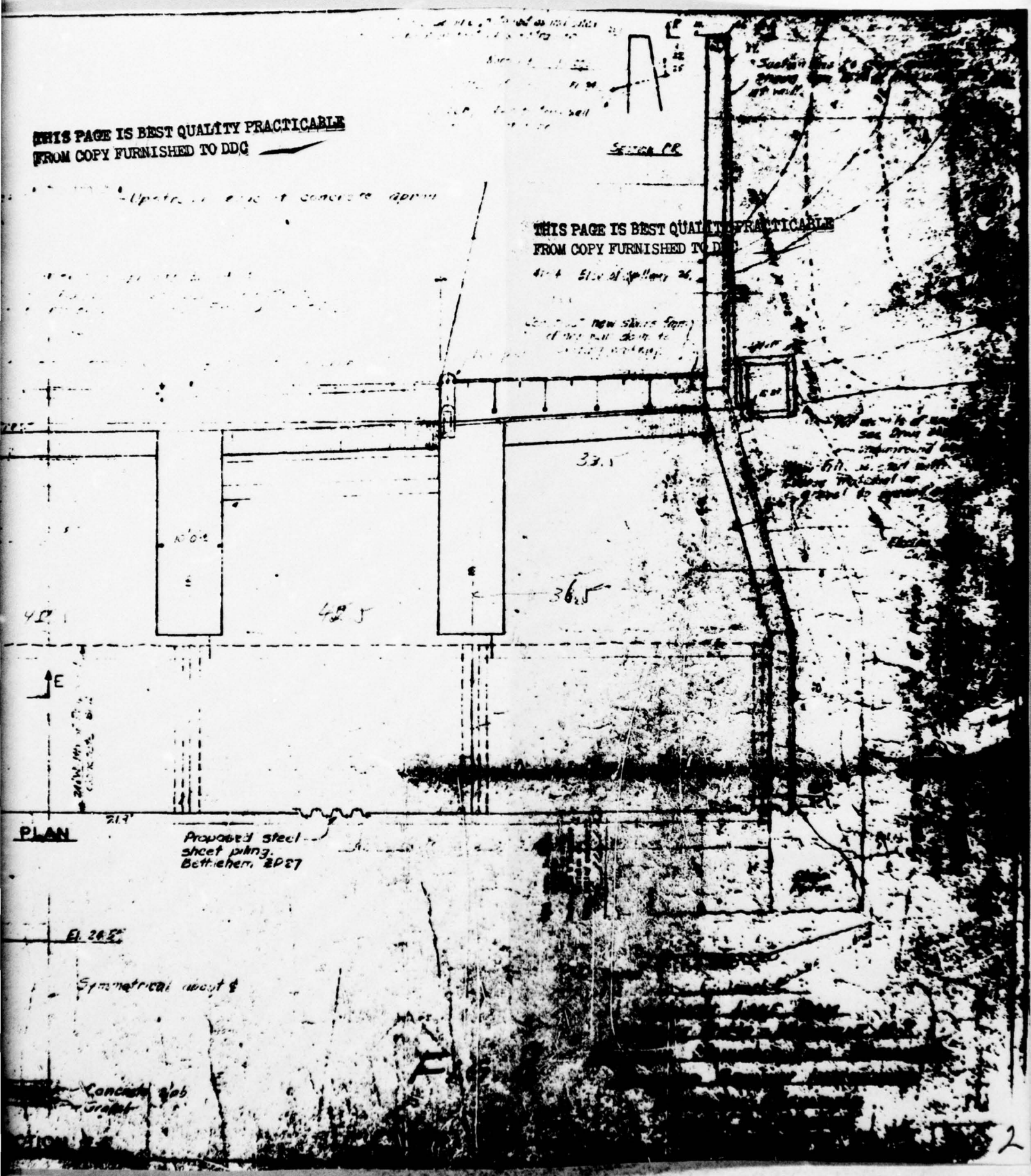
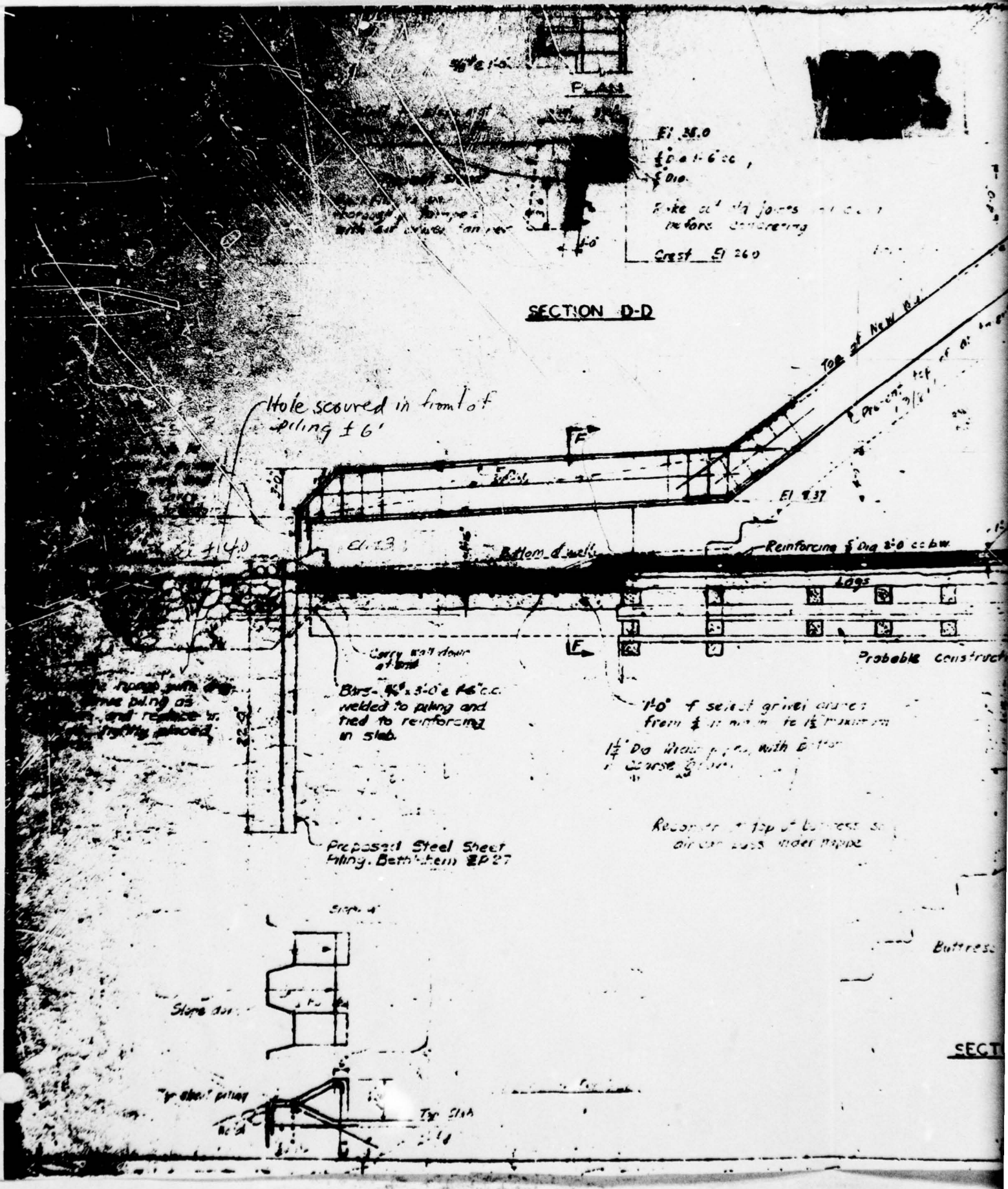


FIGURE 1
REGIONAL VICINITY MAP
SCALE 1:24,000






SECTION D-D
Hole scoured in front of piling ± 6'
Bottom of wall
Reinforcing ⅝ Dia 3'-0 c.c. bw
Logs
Probable construct
Bars- ⅝" x 3'-0" @ 4'-6" c.c. welded to piling and tied to reinforcing in slab.
Proposed Steel Sheet Piling. Bethlehem EP 27
Buttress
Slope
Typ Slab

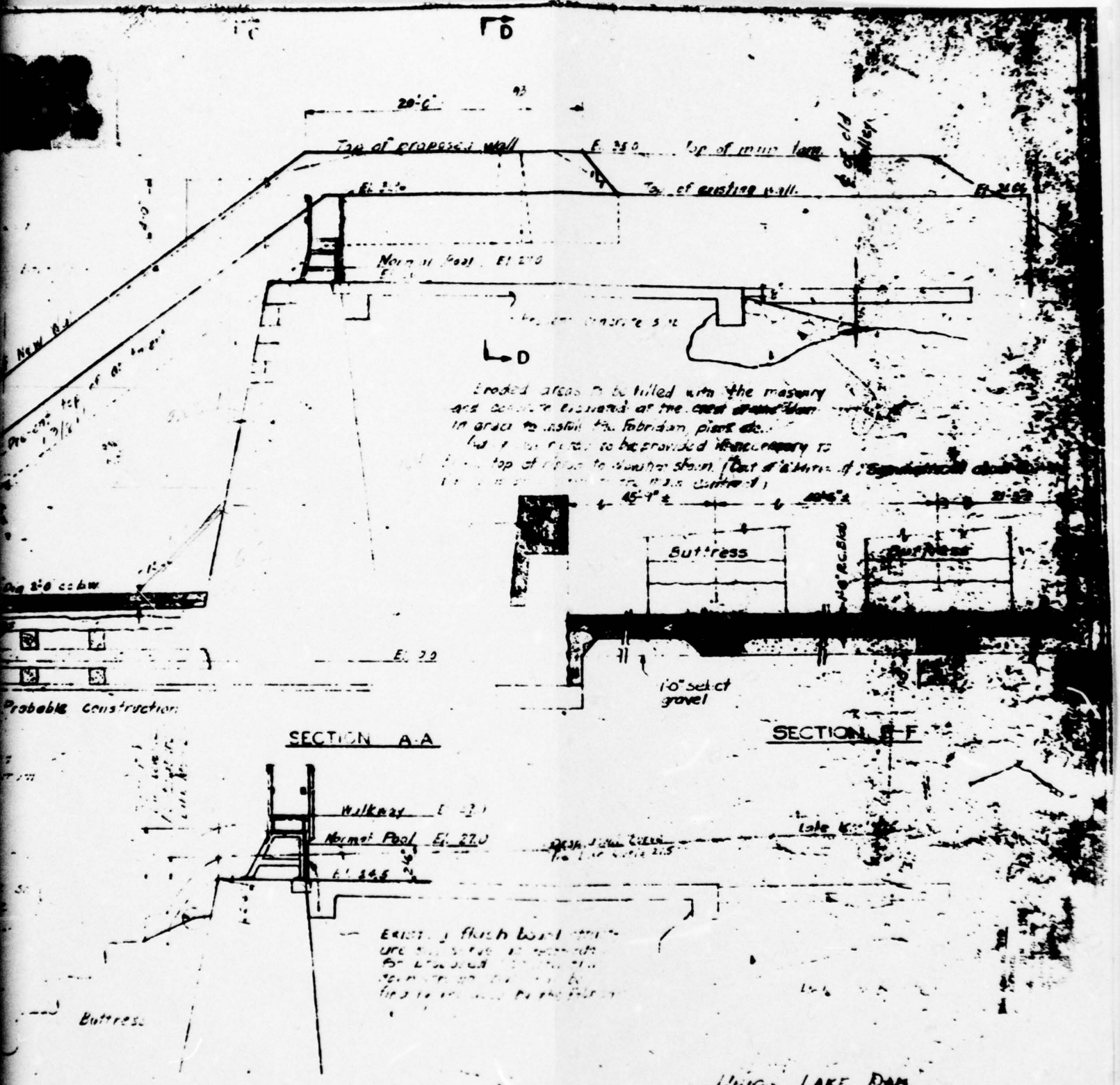


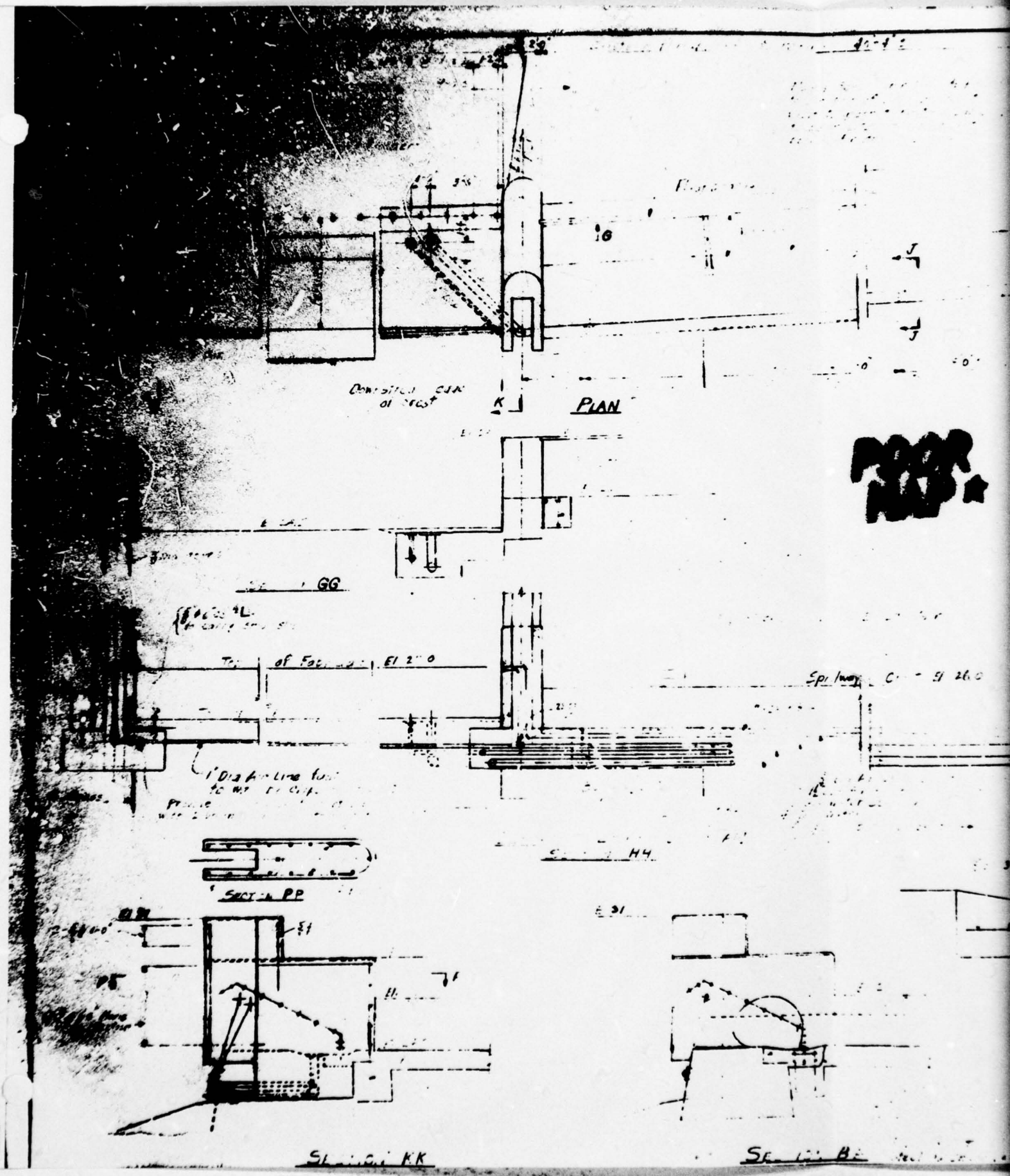
FIG. 3

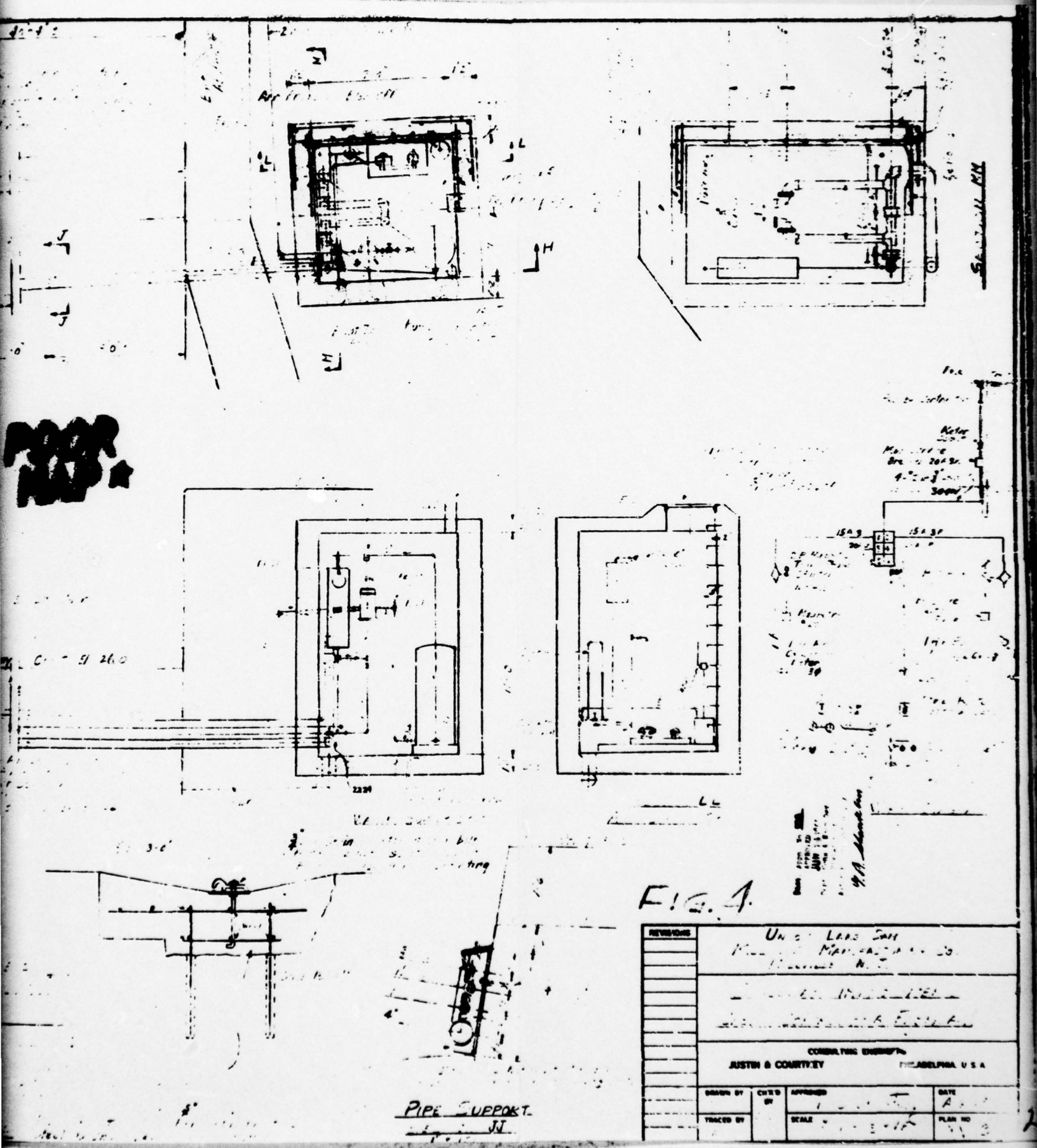
UNION LAKE DAM

PROPOSED SPILLWAY

SECTIONS

2


PLAN
GG
SECTION PP
SECTION KK
SECTION BB



PIPE SUPPORT
JJ

FIG. 1.

JUSTIN & COURTNEY

Condition Report - Dams

Application No. 578

Name of Dam UNION LAKE DAM

Owner's Name MILLVILLE MANUFACTURING Co.

Address 829 COLUMBIA AVE. MILLVILLE NJ 08332

RECEIVED
AUG 7 11 27 AM '73
DEPT. ENVIR. PROTECT. DIV. OF WATER RESOURCES

Description of condition of the following:

1. Embankment (Erosion, seepage, etc.)
   NO EROSION OF EMBANKMENT
   SEEPAGE SAME AS FIRST OBSERVED IN 1945
2. Spillway (Concrete spalling, timber rotting, leakage, etc.)
   SPILLWAY IS MASONRY, CONSTRUCTED ABOUT 100 YEARS AGO.
   LEAKAGE NEGLIGIBLE
3. Emergency Spillway (Erosion, growth of sod, riprap, etc.)
   NONE
4. Outlet Works (Operational condition of valves or gates, condition of pipe, etc.)
   NO OUTLET WORKS. AN HYDRO-ELECTRIC UNIT USING ABOUT 300 C.F.S OPERATES OFF A CANAL LEADING FROM LAKE.
5. Inlet streams (Silt deposition, etc.)
   NOMINAL. UPSTREAM RESERVOIRS AID IN DEPOSITION.
6. Outlet stream (Scouring, undercutting of dam, condition of stilling basin, etc.)
   STILLING BASIN RECONSTRUCTED IN 1965, APPEARS TO BE FUNCTIONING VERY SATISFACTORILY AS ROCK DOWNSTREAM OF STEEL SHEET PILE WALL
7. General SEEMS TO HAVE STABILIZED. DUMPED CONCRETE ADDED WHENEVER AVAILABLE

   a. Did flood waters overtop dam during period of report?
      If so, at what stage and date thereof.
      EARTH DAM NEVER BEEN OVERTOPPED.
      ALL FLOWS PASS OVER MASONRY SPILLWAY OR THIRD HYDRO UNIT
   b. Report on any other condition not covered above.

   c. In your opinion, does existing condition warrant repairs?
      If so, where and to what extent.
      BRUSH ON SLOPES IS PLANNED TO BE REMOVED THIS FALL

   d. Photographs of the upstream and downstream faces of the embankment, main spillway and emergency spillway noting date taken. 7 PHOTOS.

Use additional sheets when necessary.

Inspected by,

Consulting Engineer Neville A Courtney

N. J. License No. 3504

Date: AUG 27 1973

FIG. 5

Check List
Visual Inspection
Phase 1

Name Dam Union Lake County Cumberland State New Jersey Coordinators NJDSP

Date(s) Inspection 14,21,28 June Weather Rainy Temperature 82
19,20 July 1978

Pool Elevation at Time of Inspection 27.5+ M.S.L. Tailwater at Time of Inspection 2.0+ M.S.L.

Inspection Personnel:

T. Chapter M. Carter R. Lang

C. Hoffman K. Jolls

H. P. Grout

K. Jolls Recorder

CONCRETE/MASONRY DAMS SHEET 2

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SEEPAGE OR LEAKAGE	Seepage observed both sides of spillway	Flow on right side estimated at 1 cfs.
STRUCTURE TO ABUTMENT/EMBANKMENT JUNCTIONS	Satisfactory	
DRAINS	None	
WATER PASSAGES	None	
FOUNDATION	Unknown. Reputed to be willow and stone mattress.	

CONCRETE/MASONRY DAMS SHEET 3

VISUAL EXAMINATION OF	OBERSVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS CONCRETE SURFACES	None observed - masonry. Exposed concrete under water.	Old ashlar masonry. Buttressed laid up rough (No trimming).
STRUCTURAL CRACKING	None observed - masonry.	Some cavitation on spillway. Energy block at downstream base. (triangular concrete)
VERTICAL AND HORIZONTAL ALIGNMENT	Satisfactory	
MONOLITH JOINTS	N/A	
CONSTRUCTION JOINTS		Some joints in masonry on downstream face appear to leak.

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	No major cracks observed.	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	No unusual movement or slides observed.	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	Some erosion at downstream slopes.	Slopes very irregular. " cleared of major growth.
VERTICAL AND HORIZONTAL ALINEMENT OF THE CREST	Satisfactory. Width varies (20' Avg).	
RIPRAP FAILURES	Riprap on upstream face appears to have no bedding layer.	Riprap in downstream stilling basin scattered about at edges. Steel sheeting undercut at south edge of apron.

EMBANKMENT

SHEET 5

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	Location of abutment junction unknown.	
ANY NOTICEABLE SEEPAGE	Yes	Both sides of spillway.
STAFF GAGE AND RECORDER	None	
DRAINS	None	

OUTLET WORKS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	Minor cracking and spalling at east abutment headgates.	
INTAKE STRUCTURE	Intake/outlet structure same concrete unit.	
OUTLET STRUCTURE (SPILLWAY)	Sheet piling driven at downstream edge of apron.	
OUTLET CHANNEL		
EMERGENCY GATE	None	

UNGATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	Crest coated with epoxy. Fabridam operating satisfactorily. Concrete wings in good condition.	
APPROACH CHANNEL	None. Dam situated on main lake.	
DISCHARGE CHANNEL	Maurice River channel. Clear of debris. Banks stabilized. Stilling basin undercut below apron.	
BRIDGE AND PIERS	Sharp St. bridge 200' downstream. from spillway. Poor condition. Piers patched. Hydraulically inadequate.	Bridge would be overtopped with SDF.

DISCHARGE CHANNEL

GATED SPILLWAY (at East abut.)

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE SILL	Not observed.	
APPROACH CHANNEL	None. Main reservoir.	
DISCHARGE CHANNEL	Sand bar downstream from outlet apron. Clear of debris. Canal to powerhouse (1000' downstream)	
BRIDGE AND PIERS	Concrete condition satisfactory. Minor cracking and spalling at inlet corners. Right top slab soffit broken off.	
GATES AND OPERATION EQUIPMENT	3-5x7 steel headgates at east abutment concrete structure. Hand-operated (very slow).	

INSTRUMENTATION

VISUAL EXAMINATION	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS	USGS B.M. east of Sharp Street bridge.	
OBSERVATION WELLS	None	
WEIRS	None	
PIEZOMETERS	None	
OTHER	None	

RESERVOIR

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	Very flat except bank at southwest slope.	
SEDIMENTATION	Unknown. Reservoir over 100 years old. Upper areas appear silted up and smaller contributory streams braided.	

DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	Clear of debris. In tidal zone (4'± variation)	
SLOPES	Gradient very flat.	
APPROXIMATE NO. OF HOMES AND POPULATION	5000 ± population. Homes, school, park in flood zone.	

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION

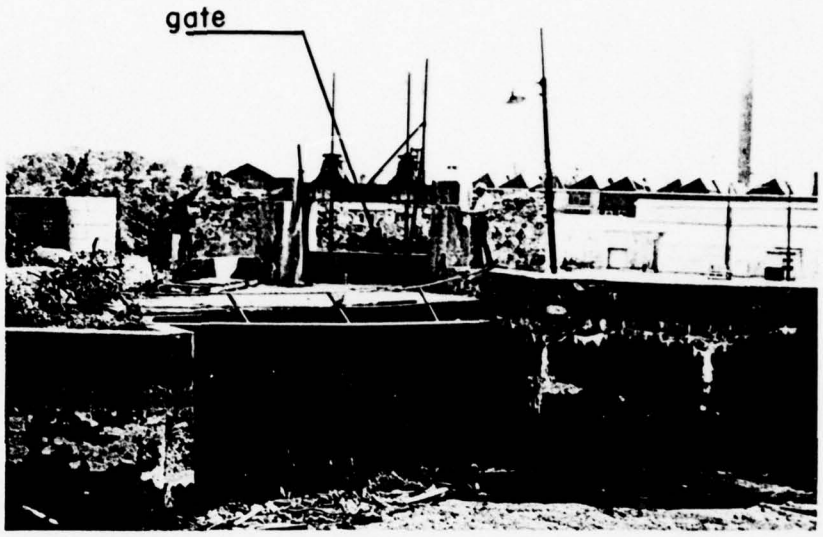
(UNION LAKE)

ITEM	REMARKS
PLAN OF DAM	Available (3 sheets)
REGIONAL VICINITY MAP	Available
CONSTRUCTION HISTORY	Unknown
TYPICAL SECTIONS OF DAM	Unavailable
HYDROLOGIC/HYDRAULIC DATA	Available data (gage station above dam)
OUTLETS - PLAN	Available
- DETAILS	Available
-CONSTRAINTS	Available
-DISCHARGE RATINGS	Available
RAINFALL/RESERVOIR RECORDS	None

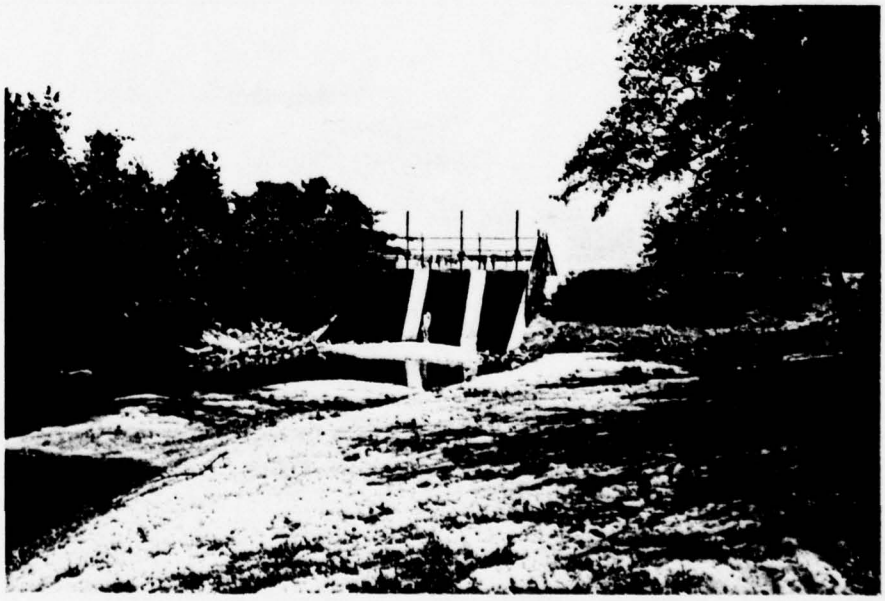
ITEM	REMARKS
DESIGN REPORTS	None
GEOLOGY REPORTS	Unavailable
DESIGN COMPUTATIONS	Some available (NJ DEP microfilm files of correspondence)
HYDROLOGY & HYDRAULICS	Some available (NJ DEP microfilm files of correspondence)
DAM STABILITY	Unavailable
SEEPAGE STUDIES	Unavailable
MATERIALS INVESTIGATIONS	None
BORING RECORDS	None
LABORATORY	N/A
FIELD	N/A
POST-CONSTRUCTION SURVEYS OF DAM	None
BORROW SOURCES.	Unknown

ITEM	REMARKS
MONITORING SYSTEMS	U.S.G.S. gage 6 miles upstream
MODIFICATIONS	1965 (addition of fabridam)
HIGH POOL RECORDS	None
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	None
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	Unknown - None
MAINTENANCE OPERATION RECORDS	None

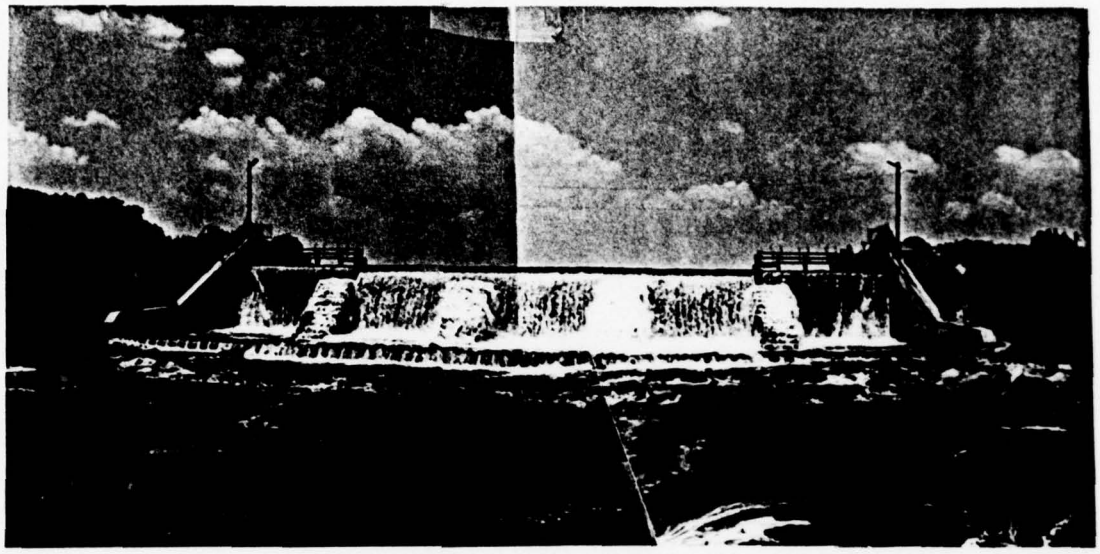
ITEM	REMARKS
SPILLWAY PLAN	
SECTIONS	Available (NJ DEP microfilm files)
DETAILS	Available (NJ DEP microfilm files)
OPERATING EQUIPMENT PLANS & DETAILS	None available.



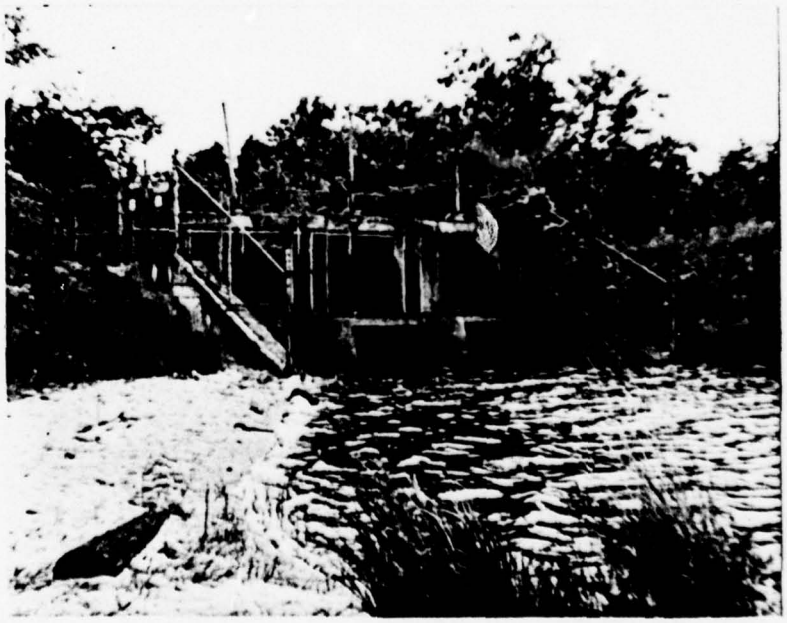
Inoperative gate to 9' Powerhouse penstock
July 1978



Sluicegates as viewed from Raceway
June 1978



Spillway
June 1978

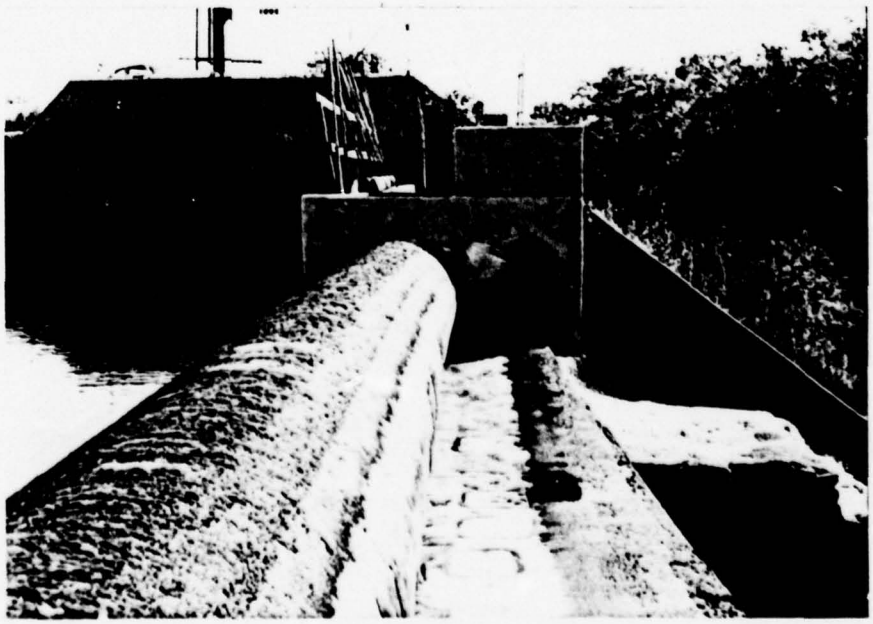


Lakeside view of Sluicegates
June 1978

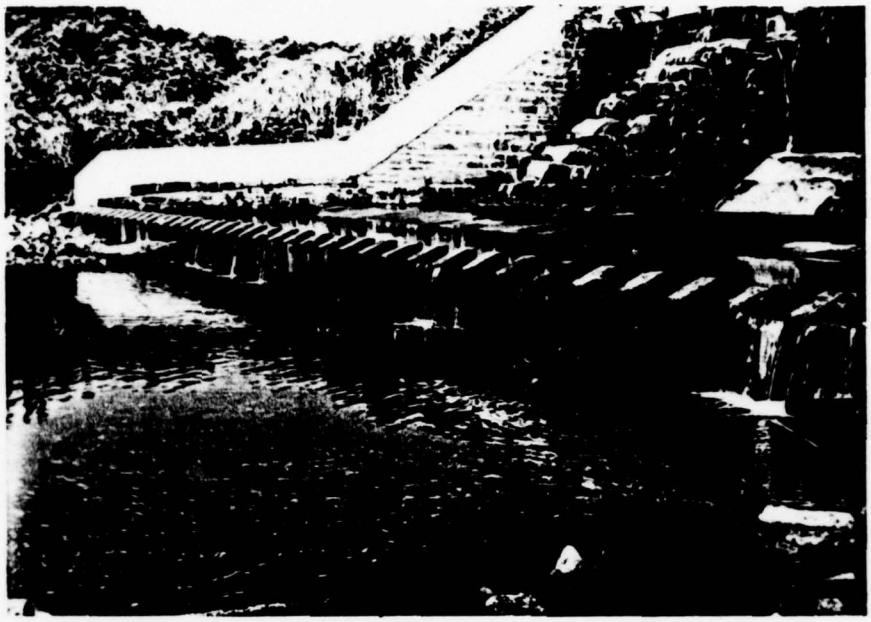
Drawdown of lake*
July 1978
*FABRIDAM DEFLATED FOR INSPECTION TEAM, 19 JULY 1978

County Bridge downstream of Spillway
July 1978

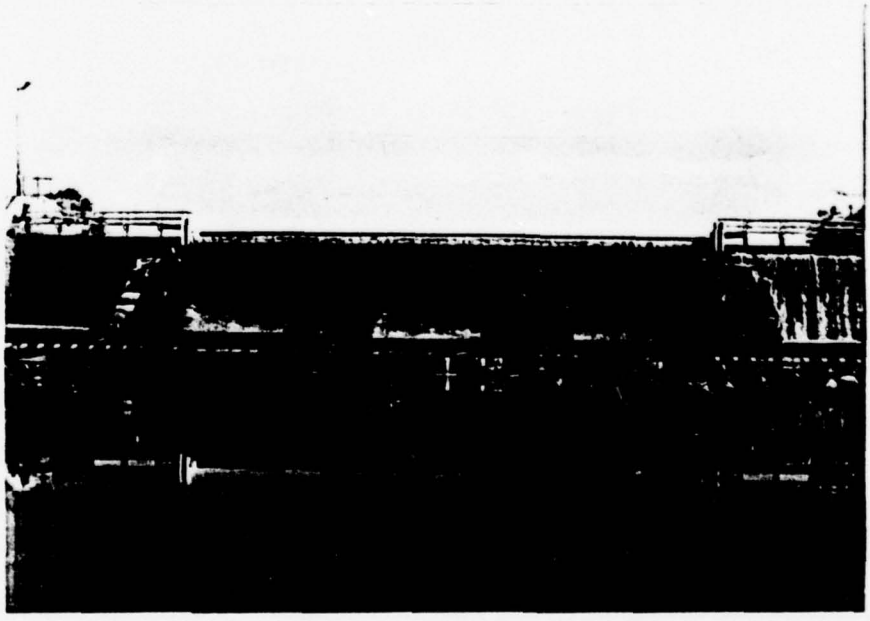
Spillway and Abutment faces
July 1978



Inflated Fabridam
July 1978



Sheet Piling at front edge of slab
July 1978



Fully Inflated Fabridam
(ON CENTRAL SPILLWAY)
July 1978

CHECK LIST
HYDROLOGIC AND HYDRAULIC DATA
ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: 218 sq. mi.

ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): 24.6 (11,600 AF)

ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): 27.0 (13,500 AF)

ELEVATION MAXIMUM DESIGN POOL: 30.5 (1965 modification)

ELEVATION TOP DAM: 35.0 (M.S.L.)

CREST:

a. Elevation Center 24.6, side spillways 26.0
b. Type Narrow crest weir
c. Width 6'±
d. Length Center 118 plus 2 @ 40'
e. Location Spillover 500' from right abutment
f. Number and Type of Gates One, rubber Fabridam

OUTLET WORKS:

a. Type 3 - 5.7'x7.0' Vert. lift headgates
b. Location Left abutment
c. Entrance inverts 20.0±
d. Exit inverts 20.0±
e. Emergency draindown facilities As above

HYDROMETEOROLOGICAL GAGES:

a. Type Water stage recorder
b. Location Norma (6 mi. upstream from Union Lk. dam)
c. Records 1932 - current

MAXIMUM NON-DAMAGING DISCHARGE: 6115 cfs (1965 Application Design)

BY D.J.M DATE 9-78 **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. A1

CHKD. BY ____ DATE ____ UNION LAKE DAM INSPECTION PROJECT C222

SUBJECT Precipitation & unitgraph data for HEC 1 input

length of longest water course ≈ 21.30 miles = L

length to centre of area ≈ 9.5 miles = Lca.

∴ L Lca ≈ 202

from curve # 2 (over leaf) Snyders t_p ≈ 40 hours

Take Cp ≈ 0.43

Rainfall losses (assumed)

Initial loss = 0.5 inches

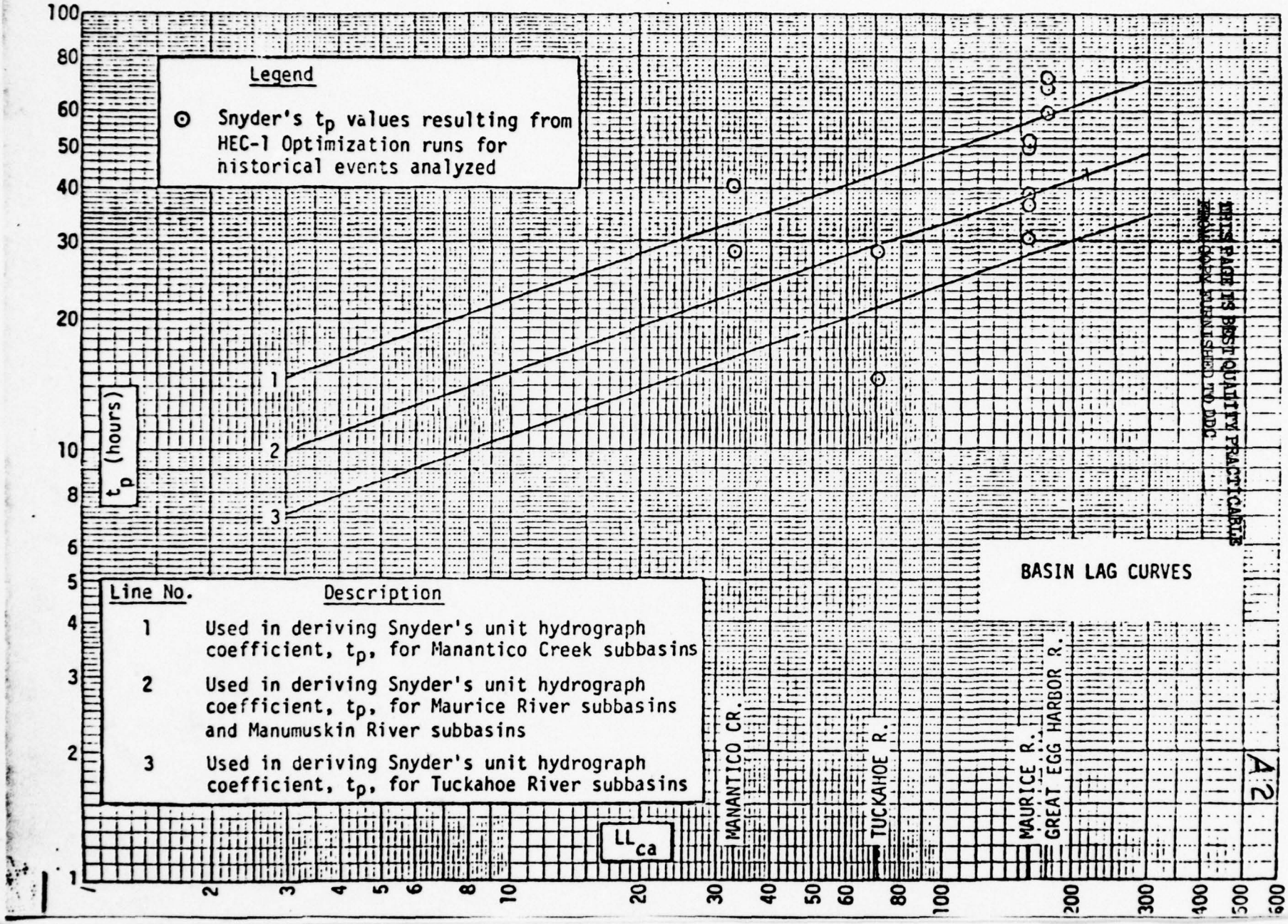
loss rate = 0.1 inches / hour

drainage area = 218 square miles

PMP For 24 hours duration & 200 square miles = 24"

From Hydromet 33

Max	6	hour	percentage	≈ 82 %
"	12	"	"	≈ 89 %
"	24	"	"	≈ 100 %
"	48	"	"	≈ 114 %


Legend
⊙ Snyder's t_p values resulting from HEC-1 Optimization runs for historical events analyzed
t_p (hours)
100
80
60
50
40
30
20
10
8
6
5
4
3
2
1
1
2
3
Line No.
Description
1 Used in deriving Snyder's unit hydrograph coefficient, t_p, for Manantico Creek subbasins
2 Used in deriving Snyder's unit hydrograph coefficient, t_p, for Maurice River subbasins and Manumuskin River subbasins
3 Used in deriving Snyder's unit hydrograph coefficient, t_p, for Tuckahoe River subbasins
LL_{ca}
2
3
4
5
6
8
10
20
30
40
50
60
80
100
200
300
400
500
600
MANANTICO CR.
TUCKAHOE R.
MAURICE R.
GREAT EGG HARBOR R.
BASIN LAG CURVES
THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC

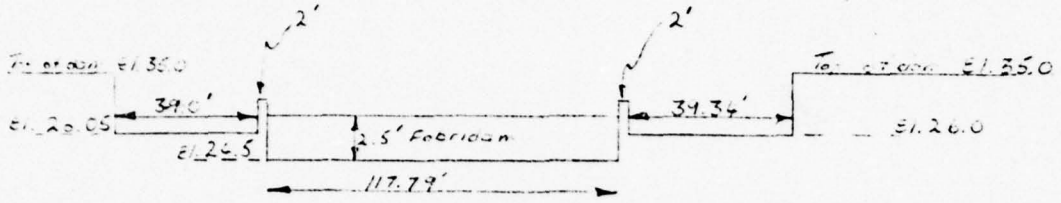
A2

BY D J M DATE 9-78 **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. A3 OF

CHKD. BY JG DATE UNION LAKE DAM INSPECTION PROJECT 0222

SUBJECT DISCHARGE CALCULATIONS

Spillway discharge :



	Fabridam L = 117.79'			Right overflow L = 39.34' crest at El. 26.0			Left overflow L = 39' crest @ El. 26.05			Abut L = 4' @ El. 28.0			
Elev.	H	C	Q	H	C	Q	H	C	Q	H	C	Q	ΣQ
24.5	0												0
24.6	0												0
25.0	0.4	2.9	86										86
26.0	1.4	2.95	575										575
26.05	1.45	3.0	617										618
26.5	1.90	3.05	941	0.5	2.95	41	0.45	2.95	35				1017
27.0	2.4	3.10	1358	1.0	3.0	118	0.95	3.0	109				1584
28.0	3.4	3.1	2289	2.0	3.1	345	1.95	3.1	329				2963
29.0	4.4	3.1	3370	3.0	3.1	634	2.95	3.1	613	1.0	3.1	12	4629
30.0	5.4	3.1	4582	4.0	3.1	976	3.95	3.1	949	2.0	3.1	35	6542
32.0	7.4	3.1	7350	6.0	3.1	1792	5.95	3.1	1755	4.0	3.1	99	10996
34.0	9.4	3.1	10524	8.0	3.1	2760	7.95	3.1	2710	6.0	3.1	182	16176
35.0	10.4	3.1	12247	9.0	3.1	3293	8.95	3.1	3237	7.0	3.1	230	19007
35.1*	10.5	3.1	12424	9.1	3.1	3348	9.05	3.1	3292	7.1	3.1	235	19299
36.0*	11.4	3.1	14055	10.0	3.1	3857	9.95	3.1	3795	8.0	3.1	281	21988

* Dam is overtopped for this value (top of dam El. 35.0)

BY D.J.H. DATE 8-78 **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. A 4 OF
CHKD. BY DATE UNION LAKE DAM INSPECTION PROJECT C222
SUBJECT DISCHARGE DATA

0.1 feet overtopping of the entire dam.

Dam length 2,100 feet.

Subtract length of Spillway 200' (approximately)

Gives Effective length of 1,900 feet.

$H = 0.1$ feet

$C = 2.7 \pm$

$Q = 0.1^{1.5} \times 2.7 \times 1,900 = 162$ cfs

Total Q at 0.1 feet overtopping $= 19299 + 162$
$= 19,461$ cfs

With 1.0 feet overtopping $H = 1.0$ $C = 2.8 \pm$

Q over dam $= 1.0^{1.5} \times 2.8 \times 1,900$
$= 5320$

Total Q $= 5320 + 21,988$

$= 27,308$

@ El. 40.0 For flow around dam:

$L = 2500$ depth $\approx 5'$

Area = 12,500 sq feet

Assume velocity of 2.5 feet s^{-1}

gives $Q = 12,500 \times 2.5 \approx 31,000$ cfs

flow over dam – spillway:

$L = 1400'$ $C = 2.8$

$H = 5'$

$\therefore Q = 1400 \times 2.8 \times 5^{1.5} \approx 59,480$ cfs

Q over spillway $\approx$ 37540 from previous table

@ El. 40.0 $\Sigma Q = 37,540 + 59,480 + 31,000$

$= 128,020$ cfs

BY D.J.M DATE 8-78 **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. A9 OF 6

CHKD. BY _____ DATE _____ UNION LAKE DAM INSPECTION PROJECT S-222

SUBJECT SUMMARY OF STORAGE & DISCHARGE DATA AS USED IN HEC 1

El. Above Sea level	Discharge cfs	Storage Acre feet
26	575	1,000
27	1,584	1,500
28	2,963	3,000
29	4,629	4,250
30	6,542	5,697
32	10,996	8,750
34	16,176	12,250
35	19,007	14,100
35.1	19,461	14,300
36.0	27,308	16,000

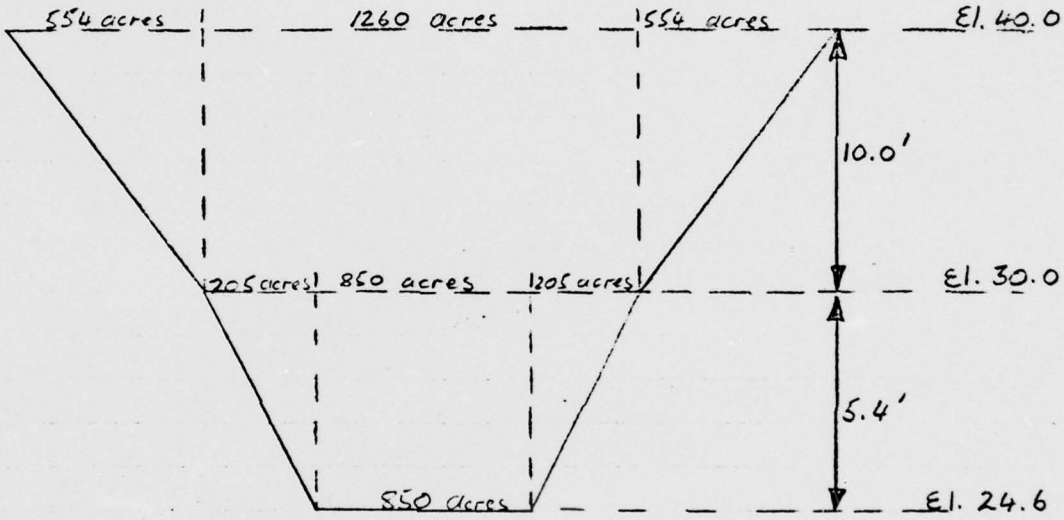
BY D.J.H. DATE 8-78 **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. A-10 OF 7

CHKD. BY ..... DATE ..... UNION LAKE DAM INSPECTION PROJECT C222

SUBJECT STAGE / STORAGE DATA FOR HEC 1 INPUT

Planimetered areas :-

Area of lake = 850 Acres
30' CONTOUR = 1260 Acres
40' CONTOUR = 2368 Acres



At El. 24.6 Storage taken as zero for routing

assuming constant slope between elevations (as drawn)

Storage 24.6 → 30.0

= 5.4 × (850 + 205)

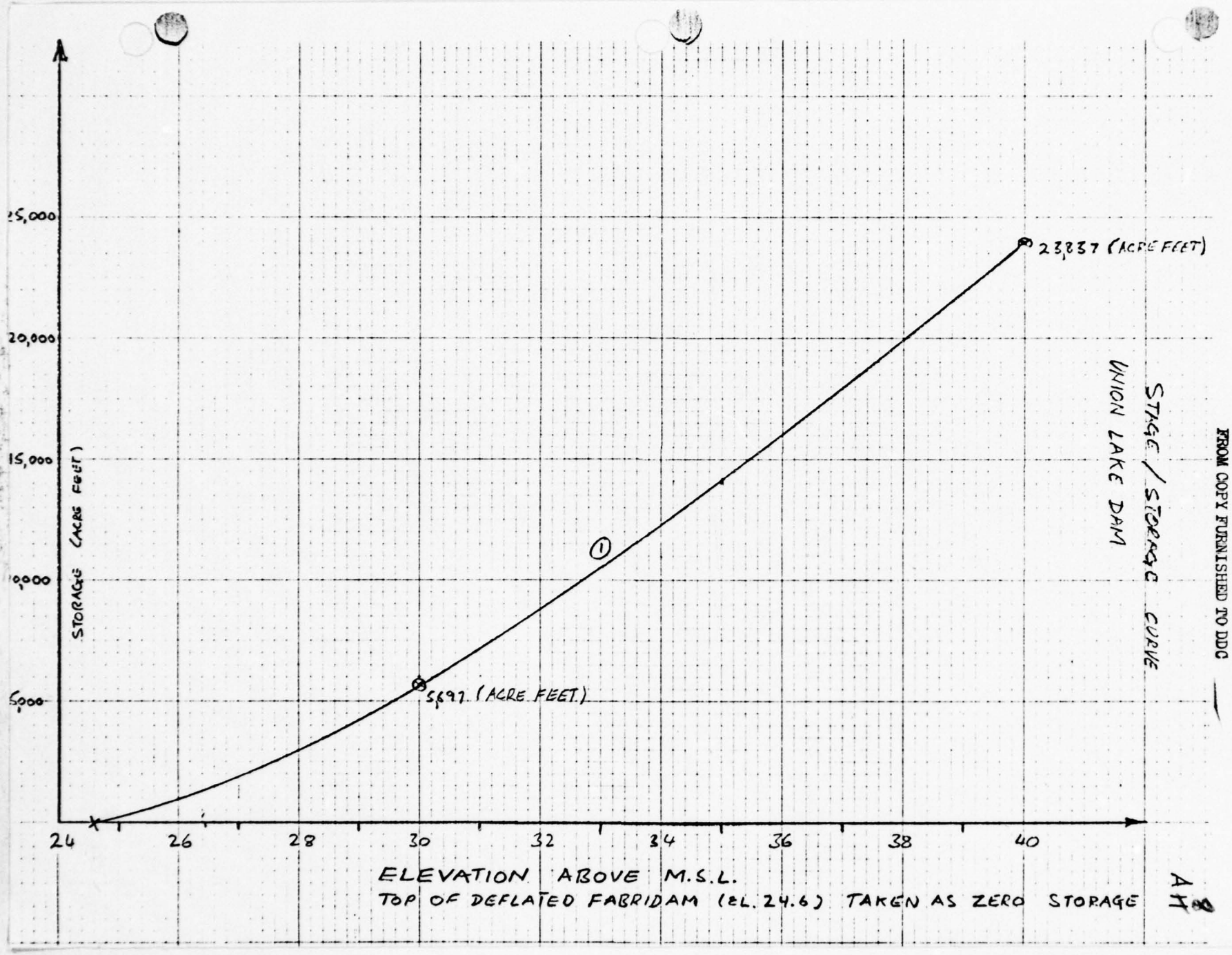
= 5,697 Acre feet

Total storage 24.6 → 40.0

= 5697 + (10 × (1260 + 554))

= 23,837 Acre feet

Stage / storage curve overleaf.



BY. D.J.M. DATE 8-76

CHKD. BY. DATE

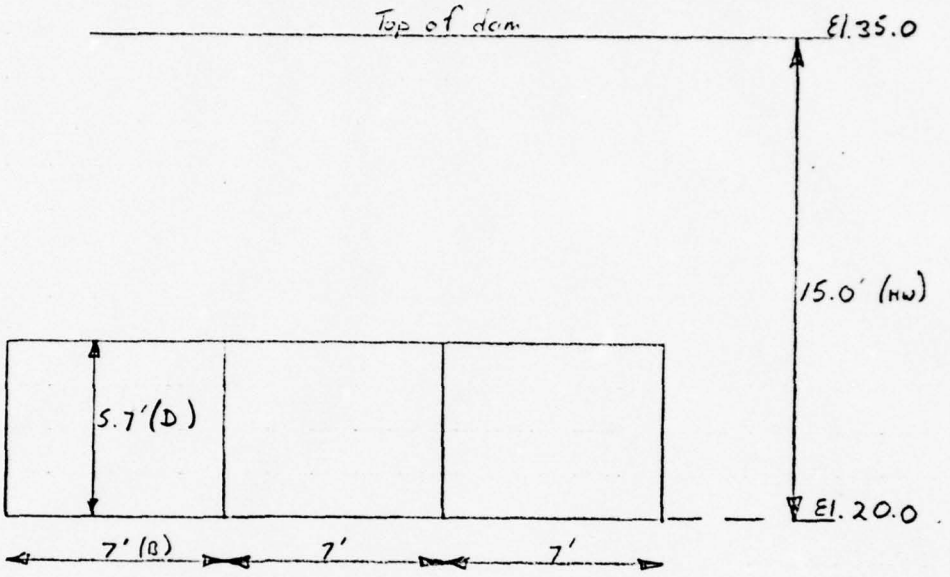
SUBJECT. DISCHARGE CAPACITY OF THREE 5.7' x 7' SLUICES

LOUIS BERGER & ASSOCIATES INC.

SHEET NO. A12 OF.

PROJECT C222

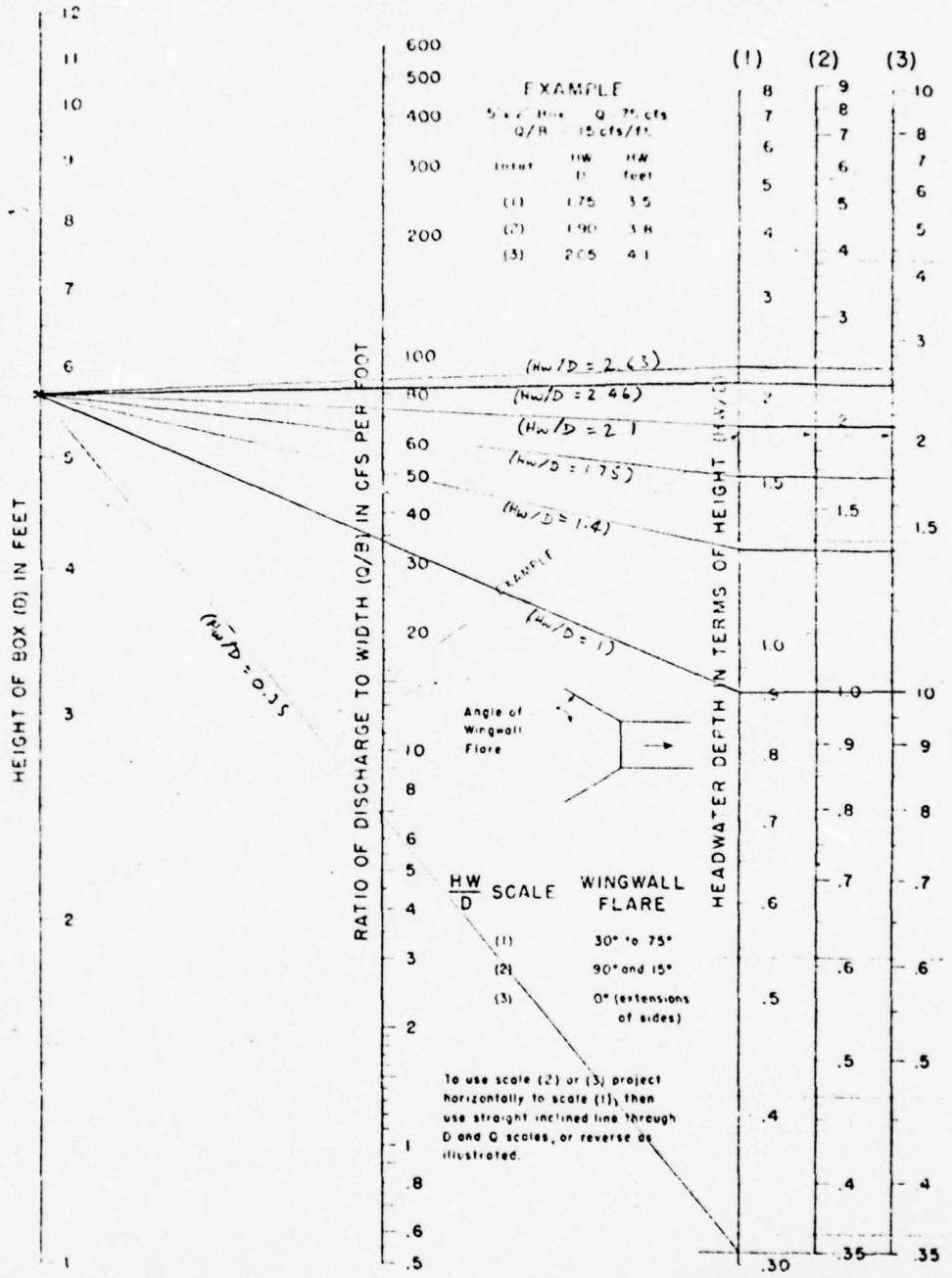
UNION LAKE DAM INSPECTION



Discharge under different heads taken from nomograph overleaf from Bureau of Public Roads publication Jan 1963

Head in feet	Hw/D	Discharge for 1' width	Discharge for 7' width	Discharge for all three
2.0	0.35	7	49	147
5.7	1	34	238	714
8.0	1.4	51	357	1071
10.0	1.75	63	441	1323
12.0	2.1	74	518	1554
14.0	2.46	82	574	1722
15.0	2.63	88	616	1848

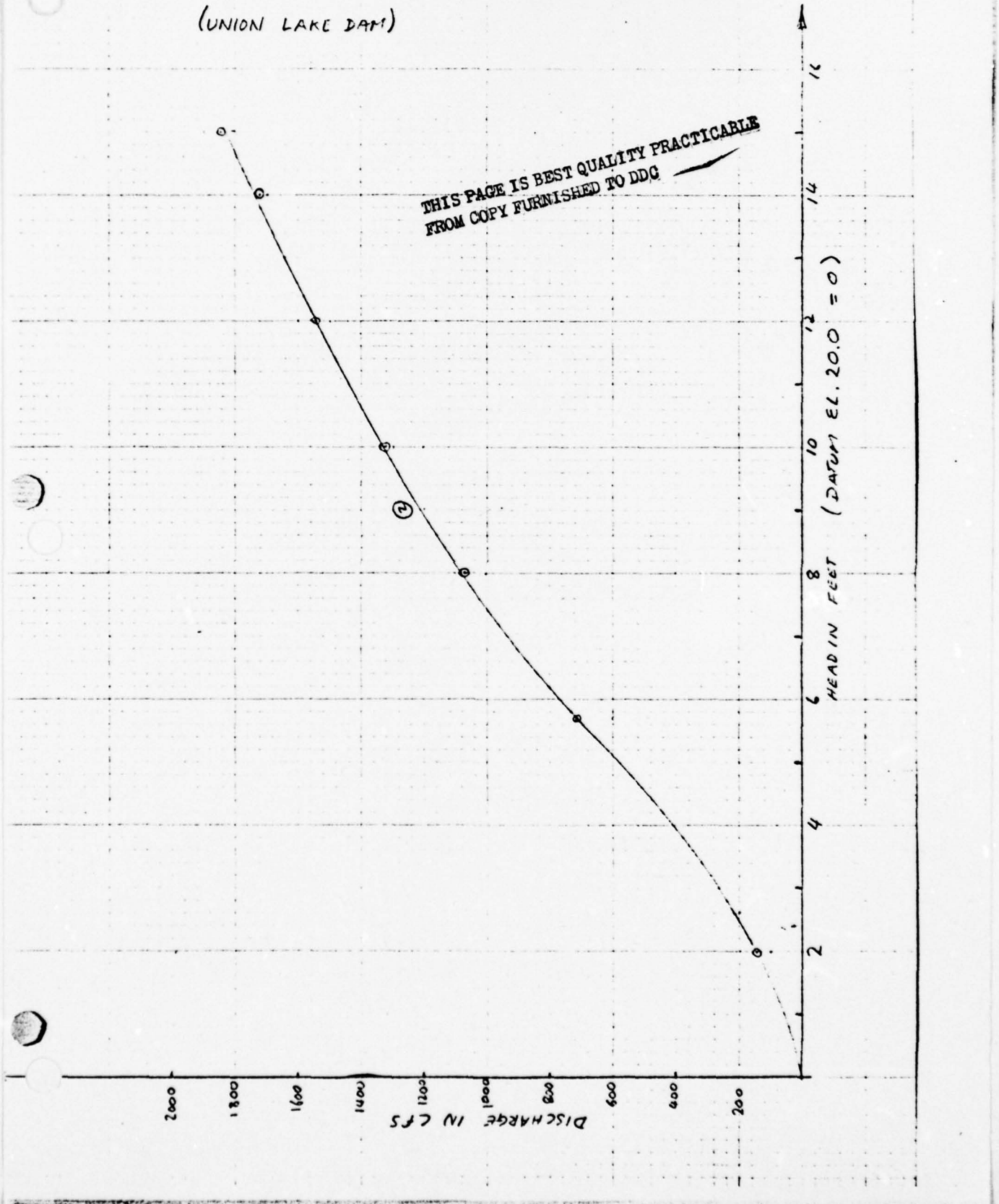
CHART 1



HEADWATER DEPTH FOR BOX CULVERTS WITH INLET CONTROL

A 1

DISCHARGE CURVE FOR THREE 7'X 5.7' SLUICEWAYS
(UNION LAKE DAM)



BY D.J.M. DATE 8-78 **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. A.12 OF.

CHKD. BY ____ DATE ____ UNION LAKE DAM INSPECTION PROJECT C222

SUBJECT Approximate drawdown calculations

Section ① El 31.0 → 35.0

Area at El. 35 = $(2368 - 1260) \times \frac{5}{10} + 1260$ = 1814 acres
= 79,017,840 sq feet

Area at El. 31 = $(2368 - 1260) \times \frac{1}{10} + 1260$ = 1370.8 Acres
= 59,712,048 sq feet

Vol = $\frac{(59,712,048 + 79,017,840)}{2} \times 4$ = 277459776 cubic feet

assume drawn down at head of 33.0'

rate of discharge from curve # ② = 1640 cfs

∴ time = $\frac{277,459,776}{1640 \times 3600}$ ≈ 47.0 hours

Section ② El. 27 → 31.0

Storage from curve # ①

= (7,100 - 1900) acre feet = 5200 acre feet
depth = 4 feet

Vol in cubic feet = 226,512,000

assume average head at El. 29

discharge = 1210 cfs

∴ time for discharge = $\frac{226,512,000}{1210 \times 3600}$ ≈ 52 hours

Section ③ El. 24.6 → 27.0

Storage between elevations from curve ① = 1900 acre feet depth = 2.4 feet

gives vol in cubic feet = 82,764,000

Assume head at El 25.8

gives discharge = 740 cfs

∴ time for drawdown = $\frac{82,764,000}{740 \times 3600}$ ≈ 31 hours

Section ④ El 20 → 24.6 assume vertical

Sides: Volume = 850 × 4.6 × 43560

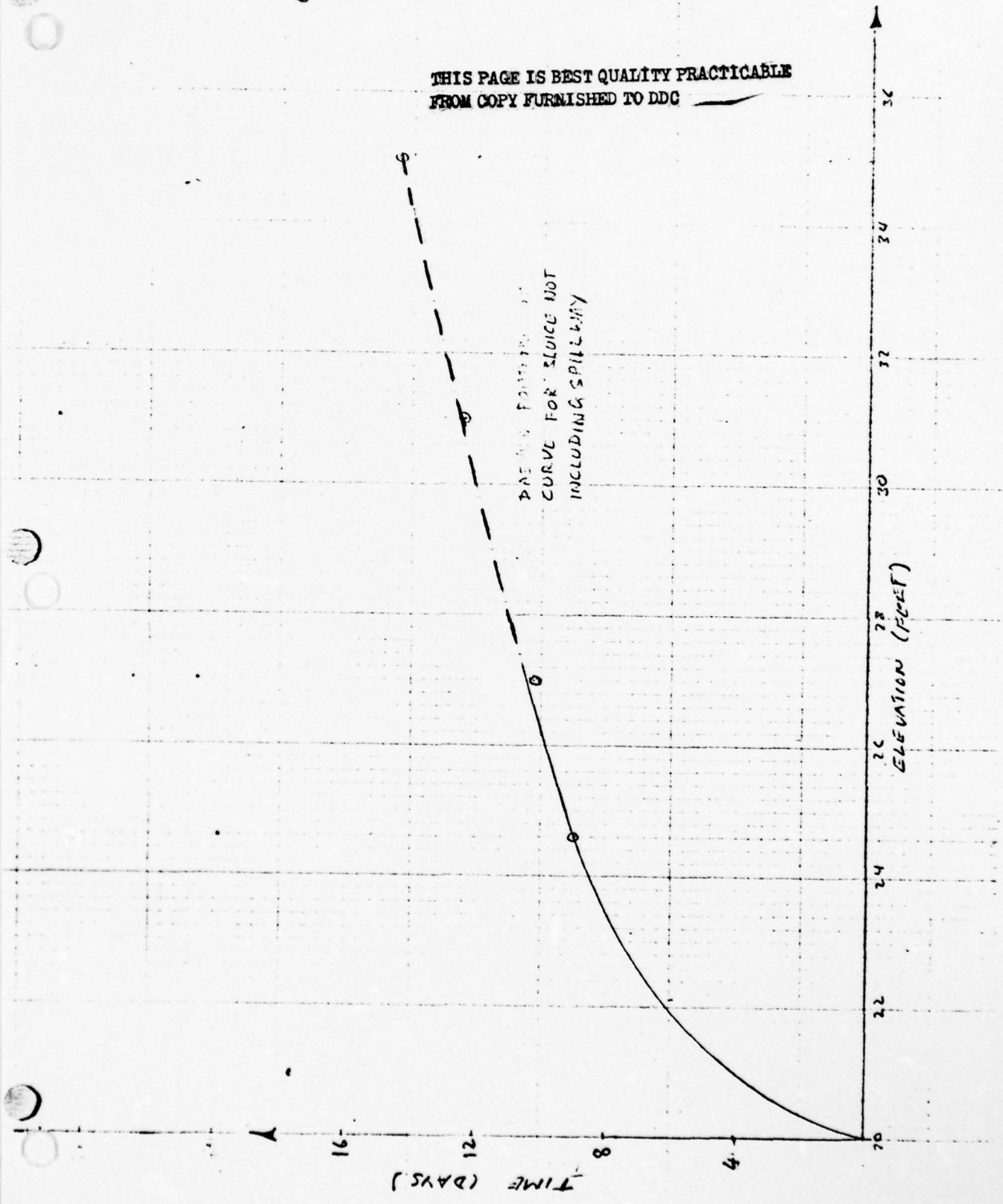
= 170,319,600 Cubic feet

discharge assuming head at El 22.3

= 220 cfs

time = $\frac{170,319,600}{220 \times 3600}$ = 215 hours

DRAWDOWN CURVE FROM EL. 20 → 27
Assuming no inflow into the reservoir



```
**************************
C-1 VERS    DATED JAN 1973
DATED AUG
ANGE NO. 01
**************************
                    UNION LAKE DAM INSPECTION  JOB#C222
                    BY D.J.MULLIGAN
                    FRIDAY SEPTEMBER 8TH 1978

                                    JOB SPECIFICATION
                        NQ    NHR  NMIN  IDAY   IHR  IMIN METRC  IPLT  IPRT NSTAN
                       150      1     0     0     0     0     0     0     0     0
                                          JOPER      NWT
                                             3        0


**********      **********      **********      **********      **********

                                SUB-AREA RUNOFF COMPUTATION

                INFLOW HYDROGRAPH
                            ISTAQ   ICOMP   IECON   ITAPE    JPLT    JPRT   INAME
                                3       0       0       0       2       0       1

                                          HYDROGRAPH DATA
              IHYDG    IUHG   TAREA    SNAP   TRSDA   TRSPC   RATIO   ISNOW   ISAME   LOCAL
                  1       1  218.00     0.0  218.00    0.89     0.0       0       0       0

                                          PRECIP DATA
                        SPFE     PMS      R6     R12     R24     R48     R72     R96
                         0.0   24.00   82.00   89.00  100.00  114.00     0.0     0.0

                                          LOSS DATA
              STRKR   DLTKR   RTIOL   ERAIN   STRKS   RTIOK   STRTL   CNSTL   ALSMX   RTIMP
                0.0     0.0    1.00     0.0     0.0    1.00    0.50    0.10     0.0     0.0

                                      UNIT HYDROGRAPH DATA
                                  TP= 40.00    CP=0.43    NTA=  0

                                          RECESSION DATA
                                STRTQ=     0.0      QRCSN=     0.0      RTIOR= 1.00
ARK DID NOT CONVERGE TO GIVEN SNYDER COEFFICIENTS
PROXIMATE CLARK COEFFICIENTS FROM GIVEN SNYDER CP AND TP ARE TC=40.51 AND R=67.38 INTERVALS

        UNIT HYDROGRAPH100 END-OF-PERIOD ORDINATES, LAG=  40.23 HOURS, CP= 0.43  VOL= 0.69
     6.      22.      45.      74.     107.     143.     183.     225.     270.     317.
   366.     418.     470.     525.     581.     638.     697.     757.     818.     880.
   943.    1005.    1063.    1119.    1171.    1221.    1268.    1312.    1353.    1391.
  1426.    1457.    1485.    1510.    1531.    1549.    1562.    1571.    1575.    1572.
  1559.    1538.    1516.    1493.    1471.    1450.    1428.    1407.    1387.    1366.
  1346.    1326.    1307.    1287.    1268.    1250.    1231.    1213.    1195.    1178.
  1160.    1143.    1126.    1110.    1093.    1077.    1061.    1046.    1030.    1015.
  1000.     986.     971.     957.     943.     929.     915.     902.     888.     875.
   862.     850.     837.     825.     813.     801.     789.     777.     766.     755.
   743.     732.     722.     711.     701.     690.     680.     670.     660.     650.

                                  END-OF-PERIOD FLOW
                                TIME   RAIN   EXCS   COMP Q
                                   1   0.02   0.00       0.
```


A15

2	0.02	0.00	0.
3	0.02	0.00	0.
4	0.02	0.00	0.
5	0.02	0.00	0.
6	0.02	0.00	0.
7	0.03	0.00	0.
8	0.03	0.00	0.
9	0.03	0.00	0.
10	0.03	0.00	0.
11	0.03	0.00	0.
12	0.03	0.00	0.
13	0.25	0.05	0.
14	0.29	0.19	2.
15	0.37	0.27	8.
16	0.93	0.83	23.
17	0.34	0.24	51.
18	0.27	0.17	92.
19	0.03	0.00	142.
20	0.03	0.00	200.
21	0.03	0.00	264.
22	0.03	0.00	334.
23	0.03	0.00	409.
24	0.03	0.00	488.
25	0.16	0.06	571.
26	0.16	0.06	659.
27	0.16	0.06	752.
28	0.16	0.06	849.
29	0.16	0.06	951.
30	0.16	0.06	1058.
31	0.25	0.15	1170.
32	0.25	0.15	1289.
33	0.25	0.15	1414.
34	0.25	0.15	1546.
35	0.25	0.15	1685.
36	0.25	0.15	1830.
37	1.75	1.65	1988.
38	2.10	2.00	2175.
39	2.63	2.53	2409.
40	6.66	6.56	2728.
41	2.45	2.35	3161.
42	1.93	1.83	3704.
43	0.23	0.13	4338.
44	0.23	0.13	5045.
45	0.23	0.13	5812.
46	0.23	0.13	6631.
47	0.23	0.13	7496.
48	0.23	0.13	8403.
49	0.0	0.0	9348.
50	0.0	0.0	10324.
51	0.0	0.0	11328.
52	0.0	0.0	12356.
53	0.0	0.0	13404.
54	0.0	0.0	14468.
55	0.0	0.0	15543.
56	0.0	0.0	16625.
57	0.0	0.0	17715.
58	0.0	0.0	18811.
59	0.0	0.0	19909.
60	0.0	0.0	21000.
61	0.0	0.0	22064.
62	0.0	0.0	23087.

A16

63	0.0	0.0	24061.	
64	0.0	0.0	24983.	
65	0.0	0.0	25852.	
66	0.0	0.0	26665.	
67	0.0	0.0	27422.	
68	0.0	0.0	28121.	
69	0.0	0.0	28761.	
70	0.0	0.0	29340.	
71	0.0	0.0	29856.	
72	0.0	0.0	30308.	
73	0.0	0.0	30693.	
74	0.0	0.0	31009.	
75	0.0	0.0	31251.	
76	0.0	0.0	31414.	
77	0.0	0.0	31486.	
78	0.0	0.0	31454.	
79	0.0	0.0	31313.	
80	0.0	0.0	31056.	
81	0.0	0.0	30705.	
82	0.0	0.0	30304.	
83	0.0	0.0	29883.	
84	0.0	0.0	29460.	
85	0.0	0.0	29039.	
86	0.0	0.0	28619.	
87	0.0	0.0	28202.	
88	0.0	0.0	27788.	
89	0.0	0.0	27379.	
90	0.0	0.0	26976.	
91	0.0	0.0	26578.	
92	0.0	0.0	26187.	
93	0.0	0.0	25801.	
94	0.0	0.0	25421.	
95	0.0	0.0	25046.	
96	0.0	0.0	24677.	
97	0.0	0.0	24314.	
98	0.0	0.0	23955.	
99	0.0	0.0	23602.	
100	0.0	0.0	23255.	
101	0.0	0.0	22912.	
102	0.0	0.0	22575.	
103	0.0	0.0	22242.	
104	0.0	0.0	21914.	
105	0.0	0.0	21592.	
106	0.0	0.0	21273.	
107	0.0	0.0	20960.	
108	0.0	0.0	20651.	
109	0.0	0.0	20347.	
110	0.0	0.0	20047.	
111	0.0	0.0	19752.	
112	0.0	0.0	19461.	
113	0.0	0.0	19141.	
114	0.0	0.0	18735.	
115	0.0	0.0	18287.	
116	0.0	0.0	17485.	
117	0.0	0.0	17071.	
118	0.0	0.0	16711.	
119	0.0	0.0	16465.	
120	0.0	0.0	16222.	

124	0.0	0.0	15287.
125	0.0	0.0	15026.
126	0.0	0.0	14768.
127	0.0	0.0	14514.
128	0.0	0.0	14264.
129	0.0	0.0	14018.
130	0.0	0.0	13775.
131	0.0	0.0	13476.
132	0.0	0.0	13182.
133	0.0	0.0	12892.
134	0.0	0.0	12607.
135	0.0	0.0	12325.
136	0.0	0.0	12048.
137	0.0	0.0	10812.
138	0.0	0.0	9370.
139	0.0	0.0	7612.
140	0.0	0.0	3299.
141	0.0	0.0	1743.
142	0.0	0.0	547.
143	0.0	0.0	452.
144	0.0	0.0	359.
145	0.0	0.0	267.
146	0.0	0.0	177.
147	0.0	0.0	88.
148	0.0	0.0	0.
149	0.0	0.0	0.
150	0.0	0.0	0.

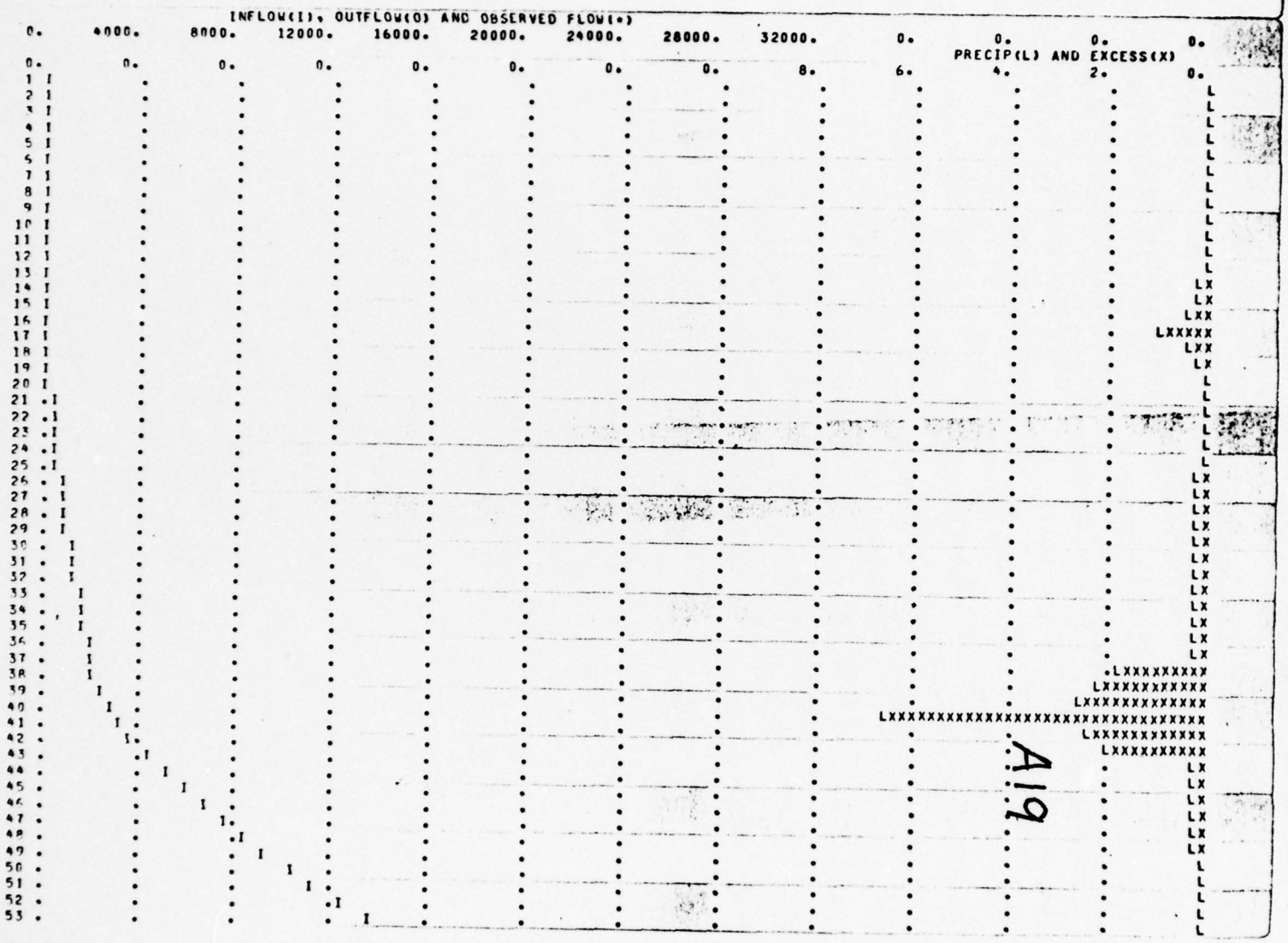
SUM 24.29 20.71 2011893.

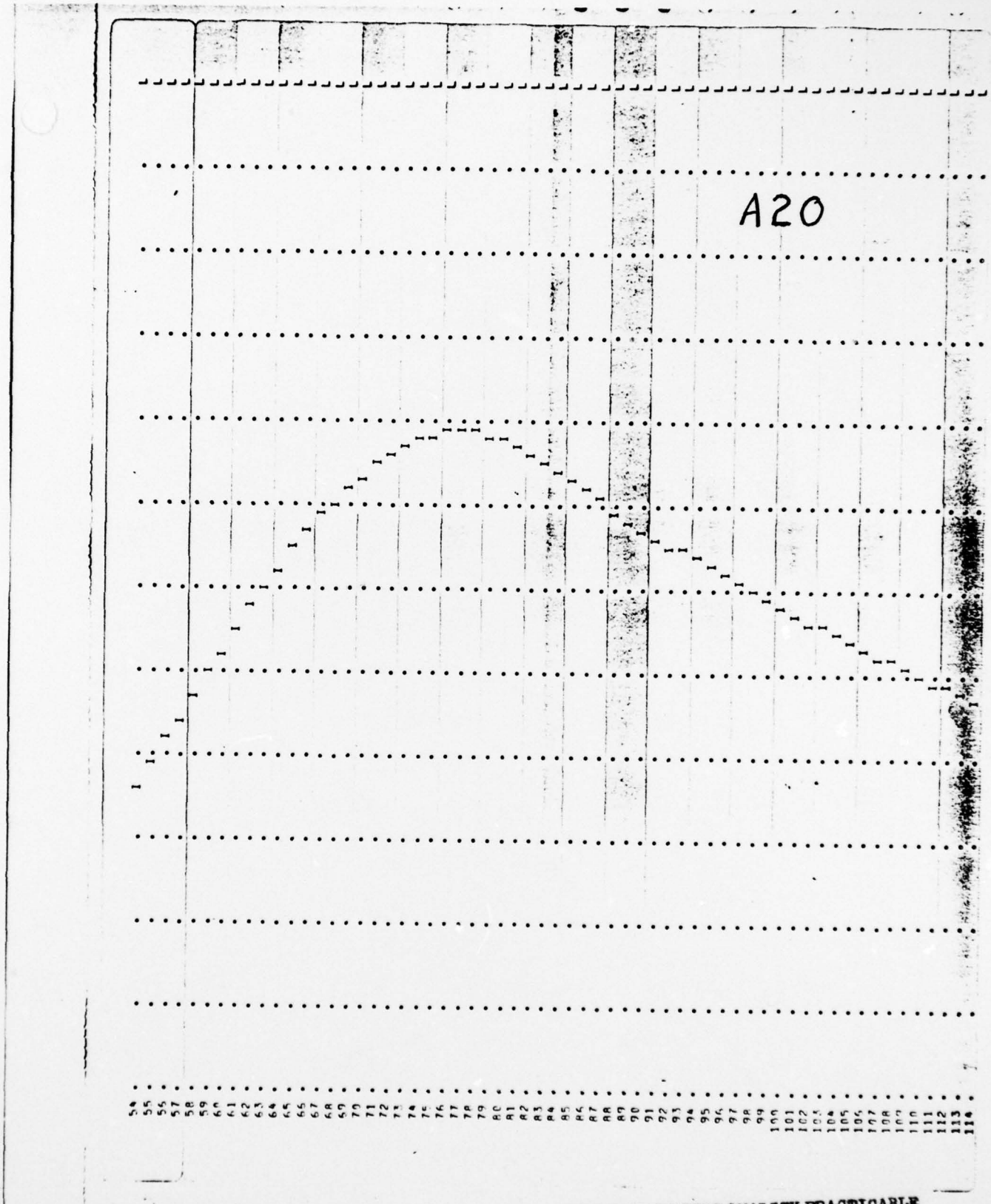
	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	31486.	31329.	29660.	23654.	2011870.
INCHES		1.34	5.06	12.11	14.31
AC-FT		15543.	58860.	140826.	166356.

A18

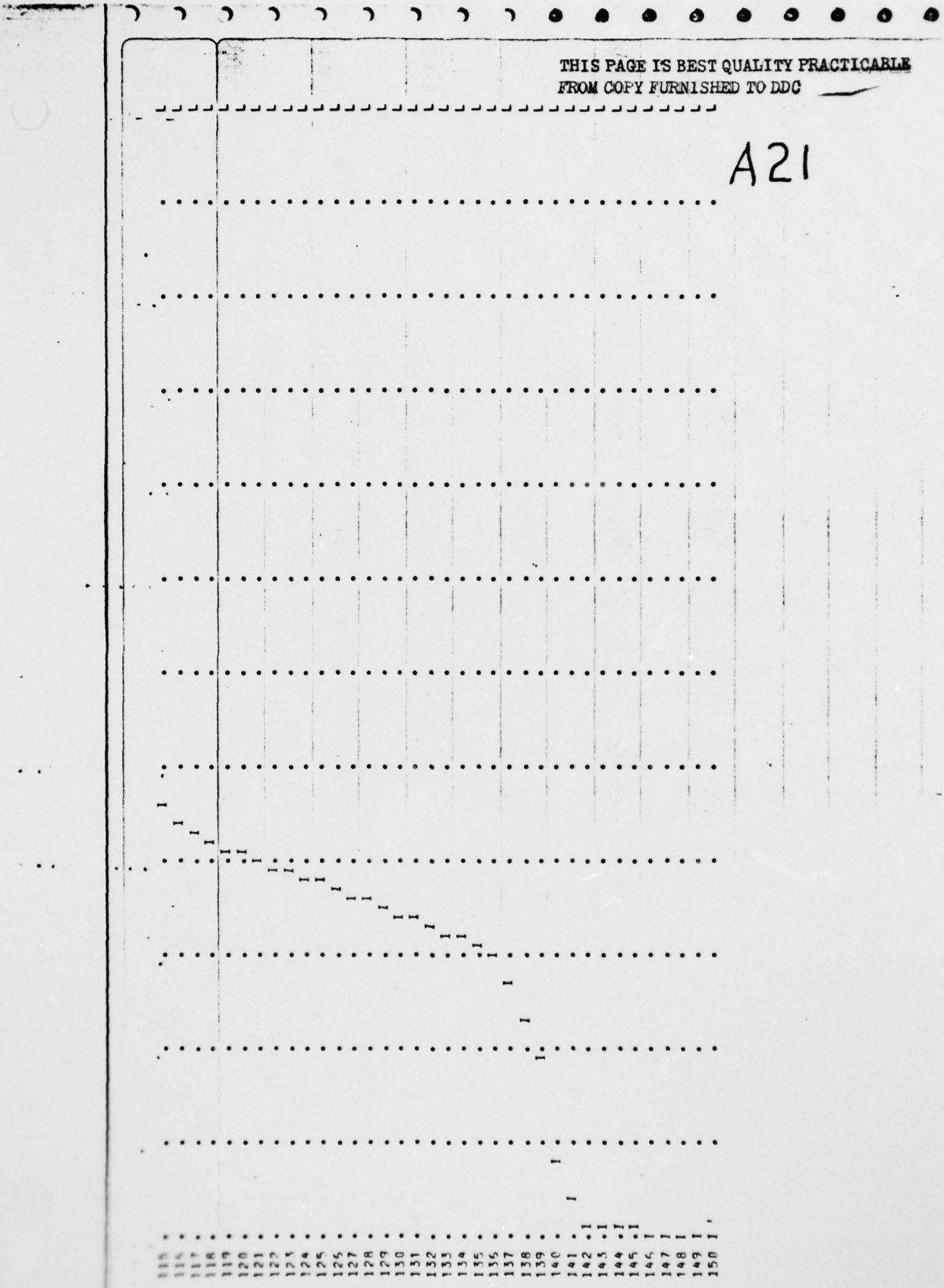
OVF

STATION 3





A21



VN•

HYDROGRAPH ROUTING

FLOOD ROUTING

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME
33	1	0	0	2	0	1

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME
0.0	0.0	0.0	1	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA
1	0	0	0.0	0.0	0.0	-1.

STORAGE=	1000.	1800.	3000.	4250.	5697.	8750.	12250.	14100.	16000.	23837.
OUTFLOW=	575.	1584.	2963.	4629.	6542.	10996.	16176.	19007.	27118.	128020.

TIME	EOP STOR	AVG IN	EOP OUT
1	1024.	0.	0.
2	1000.	0.	575.
3	955.	0.	518.
4	914.	0.	467.
5	877.	0.	420.
6	844.	0.	379.
7	815.	0.	341.
8	788.	0.	307.
9	764.	0.	277.
10	742.	0.	250.
11	722.	0.	225.
12	705.	0.	203.
13	689.	0.	183.
14	675.	1.	165.
15	662.	5.	149.
16	652.	16.	136.
17	644.	37.	126.
18	640.	71.	120.
19	639.	117.	120.
20	643.	171.	125.
21	652.	232.	136.
22	665.	299.	152.
23	682.	371.	174.
24	703.	448.	201.
25	729.	530.	233.
26	759.	615.	271.
27	793.	706.	314.
28	832.	801.	362.
29	874.	900.	416.
30	920.	1005.	474.
31	970.	1114.	538.
32	1025.	1229.	606.
33	1083.	1351.	680.
34	1146.	1480.	759.
35	1213.	1615.	844.
36	1285.	1758.	934.
37	1362.	1909.	1031.
38	1444.	2082.	1135.
39	1535.	2292.	1250.

A23

40	1639.	2568.	1380.
41	1761.	2944.	1535.
42	1911.	3455.	1712.
43	2093.	4021.	1921.
44	2312.	4692.	2172.
45	2569.	5428.	2467.
46	2865.	6221.	2808.
47	3199.	7063.	3229.
48	3569.	7950.	3721.
49	3973.	8875.	4259.
50	4410.	9836.	4840.
51	4879.	10826.	5460.
52	5379.	11842.	6121.
53	5907.	12880.	6849.
54	6460.	13936.	7655.
55	7033.	15005.	8491.
56	7625.	16084.	9354.
57	8234.	17170.	10243.
58	8859.	18263.	11157.
59	9498.	19360.	12103.
60	10148.	20454.	13065.
61	10807.	21532.	14041.
62	11472.	22575.	15025.
63	12138.	23574.	16010.
64	12800.	24522.	17017.
65	13453.	25418.	18017.
66	14093.	26258.	18997.
67	14659.	27043.	21595.
68	15107.	27771.	23307.
69	15468.	28441.	24847.
70	15763.	29050.	26107.
71	16006.	29598.	27202.
72	16162.	30082.	29202.
73	16232.	30501.	30104.
74	16272.	30851.	30623.
75	16300.	31130.	30975.
76	16319.	31333.	31223.
77	16331.	31450.	31381.
78	16336.	31470.	31442.
79	16333.	31383.	31401.
80	16321.	31185.	31251.
81	16301.	30881.	30994.
82	16275.	30504.	30654.
83	16244.	30093.	30265.
84	16212.	29672.	29853.
85	16180.	29250.	29434.
86	16147.	28829.	29014.
87	16115.	28410.	28595.
88	16082.	27995.	28178.
89	16050.	27583.	27765.
90	16019.	27177.	27357.
91	15983.	26777.	27047.
92	15937.	26382.	26848.
93	15877.	25994.	26592.
94	15808.	25611.	26297.
95	15733.	25233.	25978.
96	15655.	24862.	25643.
97	15574.	24495.	25299.
98	15492.	24135.	24950.
99	15410.	23779.	24599.
100	15328.	23429.	24248.

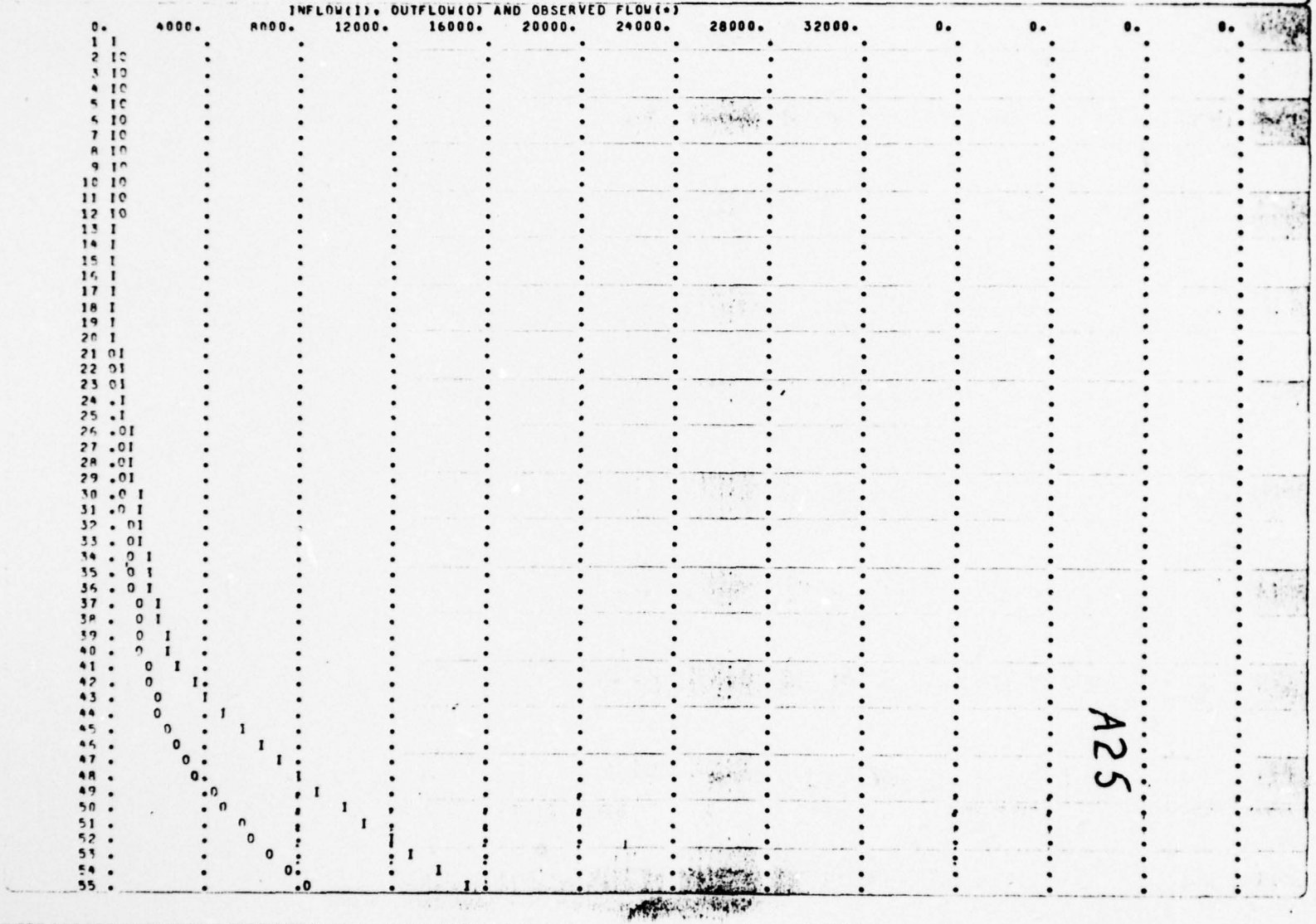
101	15246.	23083.	23899.
102	15165.	22743.	23552.
103	15084.	22408.	23209.
104	15005.	22078.	22870.
105	14926.	21753.	22535.
106	14849.	21432.	22204.
107	14773.	21117.	21878.
108	14697.	20806.	21556.
109	14623.	20499.	21239.
110	14550.	20197.	20927.
111	14478.	19900.	20619.
112	14406.	19606.	20315.
113	14335.	19301.	20011.
114	14260.	18938.	19689.
115	14177.	18511.	19336.
116	14073.	17886.	18965.
117	13941.	17278.	18764.
118	13796.	16891.	18542.
119	13644.	16588.	18309.
120	13491.	16344.	18075.
121	13338.	16103.	17841.
122	13184.	15866.	17606.
123	13031.	15632.	17371.
124	12878.	15402.	17137.
125	12724.	15156.	16901.
126	12568.	14897.	16663.
127	12411.	14641.	16422.
128	12253.	14389.	16180.
129	12094.	14141.	15945.
130	11934.	13896.	15709.
131	11772.	13626.	15469.
132	11606.	13329.	15222.
133	11435.	13037.	14970.
134	11262.	12749.	14714.
135	11087.	12466.	14455.
136	10911.	12187.	14194.
137	10695.	11430.	13875.
138	10401.	10091.	13439.
139	10015.	8491.	12869.
140	9438.	5456.	12014.
141	8699.	2521.	10921.
142	7937.	1145.	9809.
143	7211.	500.	8751.
144	6560.	406.	7802.
145	5977.	313.	6950.
146	5451.	222.	6217.
147	4974.	132.	5586.
148	4540.	44.	5012.
149	4147.	0.	4492.
150	3795.	0.	4023.
SUM			1980340.

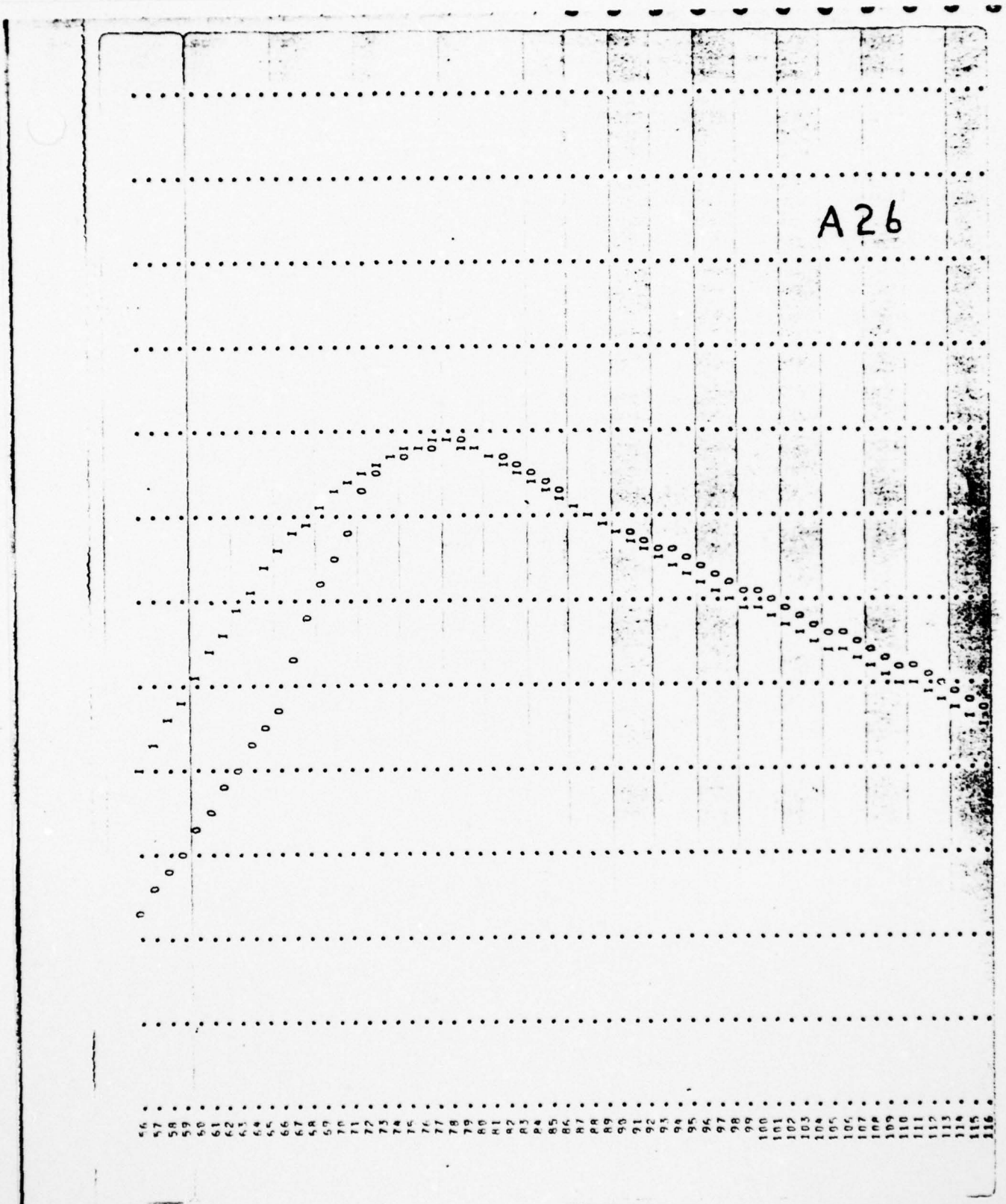
	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	31442.	31282.	29321.	23125.	1980340.
INCHES		1.33	5.00	11.84	14.08
AC-FT		15520.	58187.	137676.	163749.

•OVF•

STATION 33

INFLOW(I), OUTFLOW(O) AND OBSERVED FLOW(•)





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RUNOFF SUMMARY, AVERAGE FLOW

HYDROGRAPH AT		PEAK	6-HOUR	24-HOUR	72-HOUR	AREA
	3	31486.	31329.	29660.	23654.	218.00
ROUTED TO	33	31442.	31282.	29321.	23125.	218.00

SECURITY CLASSIFICATION OF THIS PAGE (Data Entered)

REPORT DOCUMENTATION PAGE

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18. SUPPLEMENTARY NOTES

Copies are obtainable from National Technical Information Service, Springfield, Virginia, 22151.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Dams--N.J.
National Dam Safety Program Phase I
Union Lake Dam, N.J.
Dam Safety
Dam Inspection

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report cites results of a technical investigation as to the dam's adequacy. The inspection and evaluation of the dam is as prescribed by the National Dam Inspection Act, Public Law 92-367. The technical investigation includes visual inspection, review of available design and construction records, and preliminary structural and hydraulic and hydrologic calculations, as applicable. An assessment of the dam's general condition is included in the report.

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